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A VERY FAST STEAM LAUNCH.

By PADDLEFAST.

STEAM launches, not exceeding 20 ft. long, seldom realize more than 6 miles per hour; they rarely exceed 7, and a rate between 8 and 9 miles is thought possible only with a length of 30 ft. But the little propeller Flirt, which we are about to describe, only 21 ft. long over all, easily runs at a rate of 10 miles per hour. This boat was designed and built by Mr. H. S. Maxim, and indicates, by her performance and appearance, the possession, on the part of her builder, of a rare knowledge of scientific mechanics and superior judgment in the practical use of that knowledge.

The boat carries 8 or 10 persons. Her finish is most elegant and tasteful. The trimmings are black walnut, and the engine is nickel-plated throughout. An awning may be attached to the steel flag poles at bow and stern. The waterproof cushions on the seats are life-preservers. In an unoccupied corner is a force pump to supply a blast to the furnace in getting up steam. The smokepipe is provided with a spark-arrester, which may be inserted at will; in short, every convenience is provided for the comfort and pleasure of the passenger.

The dimensions of this remarkable boat are: Length over all, 21 ft ; beam, 4 ft. 2 in.; depth, 21 in.

In Fig. 1, A is the fireman's standing room, B is a locker, C is a small fresh water tank, placed under a thwart, and under the seat at E is the pump providing the blast, and worked by a vertical lever which is removed when not used. F is the engine.

The engine is single, 3½ in. in diameter, and 3 in. stroke. The area of valve ports is 2½ in. by ¼ in. The usual cut-off is one-half. Revolutions per minute, 700.

Fig. 2 shows side view of engine and boiler. A shows the peculiar position of the pump, the piston-rod running directly into it. The reversing gear consists of a piece of tubing, B, slipping freely on the shaft. The lever, C, engages in a groove in B, thus pressing B to or fro, into or out of the drum or cylinder, D. In the drum, D, the tubing connects with a bell crank, the other arm of which throws the slotted eccentric cam, E, from one side of the shaft to the opposite. The valves may thus be completely reversed, or the eccentricity of the cam diminished any amount; hence vary the cut-off from ⅛ to ¼.

The boiler is 26 in. long, and 20 in. in diameter. It is constructed of ⅜ in. steel, tested to 72,000 lbs. The boiler was tested to 450 lbs., the bursting pressure being estimated at 900 lbs. The usual pressure with light load is from 150 to 200 lbs. The furnace is cylindrical, 11 in. in diameter and 16 in. long. The upper end of grate is about 11 in. from top of furnace. The area of grate surface is 1 sq. ft.; area of heating surface, 34 sq. ft. The flues, F F F F, are 19 in number, 1½ in. in diameter; there are 21 return tubes, G G, Fig. 3. H H indicates a T-iron brace running the length of the boiler. This brace is perforated, and prevents foaming.

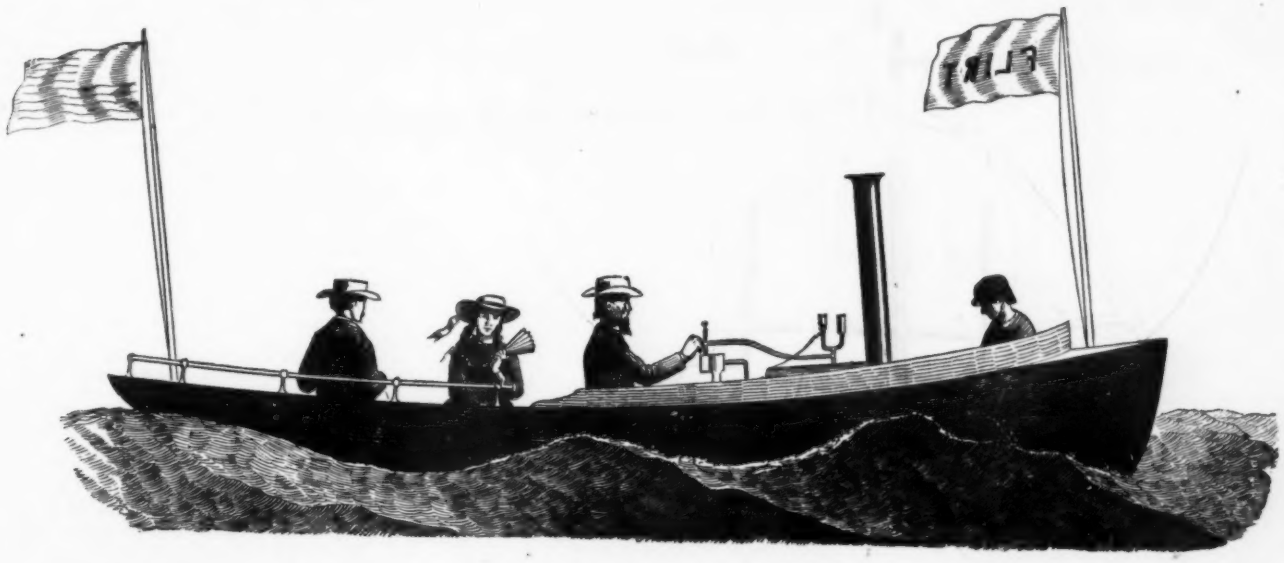
In Fig. 4, E indicates the waste pipe, running through boiler to the smokepipe. When the engine is stationary, the ¼ in. pipe, F, admits live steam into the waste pipe, to make a draft; it also discharges through pipe, G, which, by means of the flexible tube, H, clears all water from the bottom of the boat. The surface and bottom blow-offs are respectively indicated by K and J. The pump, A, receives salt water by the pipe, B. The pipe shown in cross section at C, runs aft to the fresh water tank. A steam gauge is placed at either end of boiler.

The propeller is of copper and tin, 2 bladed, and 18 in. in diameter. The pitch varies from 23 to 26 in., mean, 25 in ; and the blades are about 6 in. wide, curving forward slightly, as in the Hirsch propeller. The draft of the yacht aft, loaded, is about 32 in.

The weight of boiler is 260 lbs.; of engine, 75 lbs. Weight of machinery complete, 400 lbs. The hull is built in the lightest manner, the frames mere oak "ribbons," the planks ¼ in., and no ceiling inside. The boat is but very little heavier than the lightest rowboat of equal length, and the lines are quite as sharp. As the machinery is extremely light, the fineness of the lines is not sacrificed to an unnecessary carrying capacity, as is often the case.

The owner states that he uses salt water, and blows off one-third of all the water he uses, and is not troubled with priming. The coal used is carried in ballast bags, and employed as ballast till consumed. The stiffness of the boat is noticeable, owing to the fact that the center of gravity of the boiler stands on a level with the load waterline, and not above it, as usual.

The writer recently had the pleasure of an hour's sail with the owner in this interesting craft, part of the distance through the roughest waters of New York Bay. The swells of passing steamers, combined with the chopping sea raised by the tide, made as severe a test as could be wished. The little boat leaped over the waves with re-



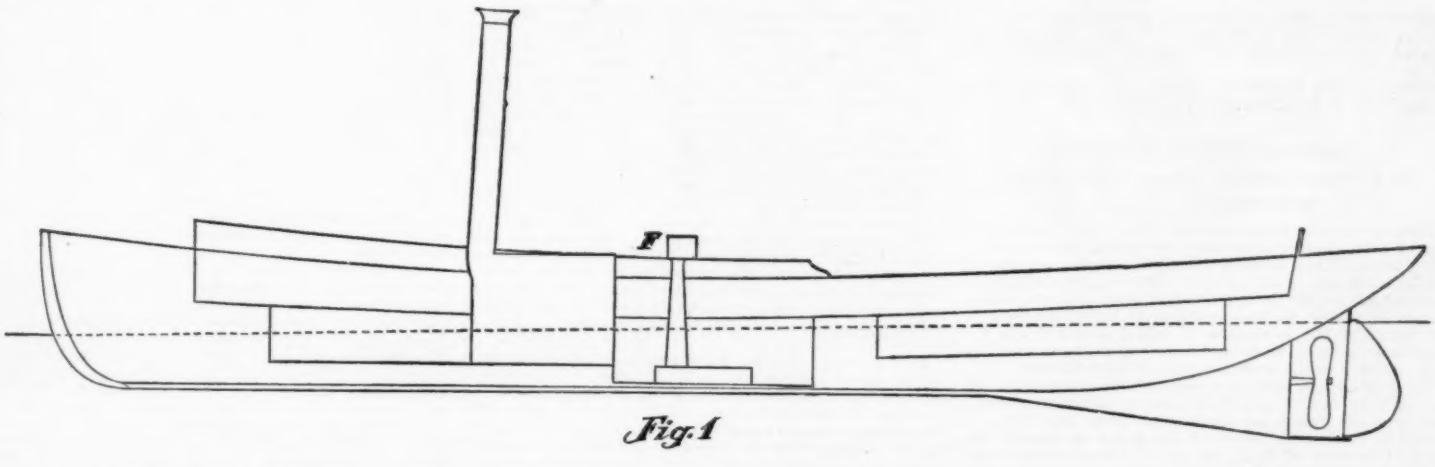
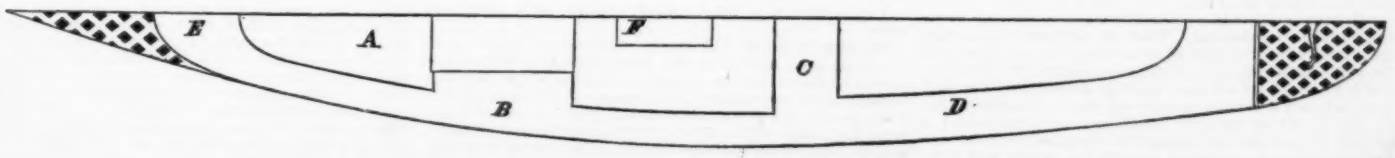
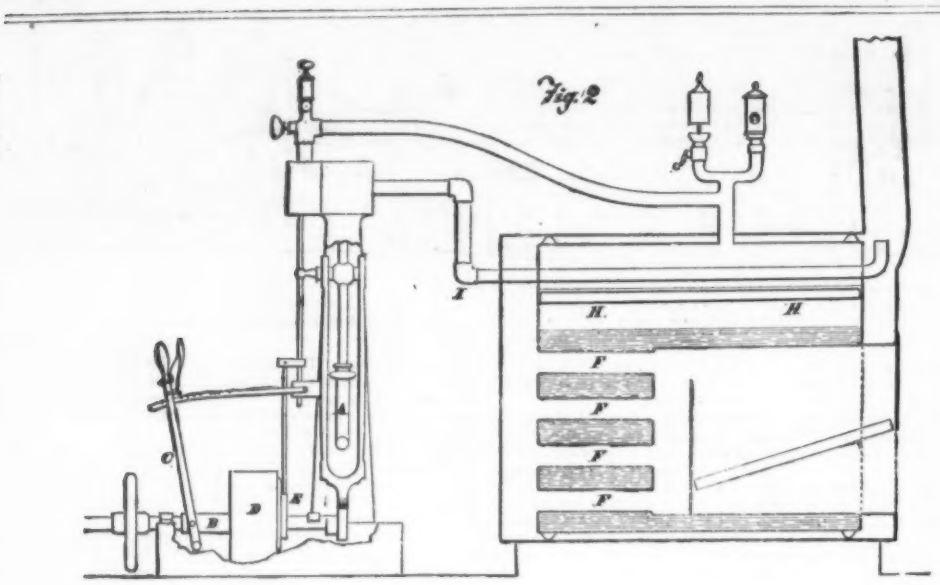
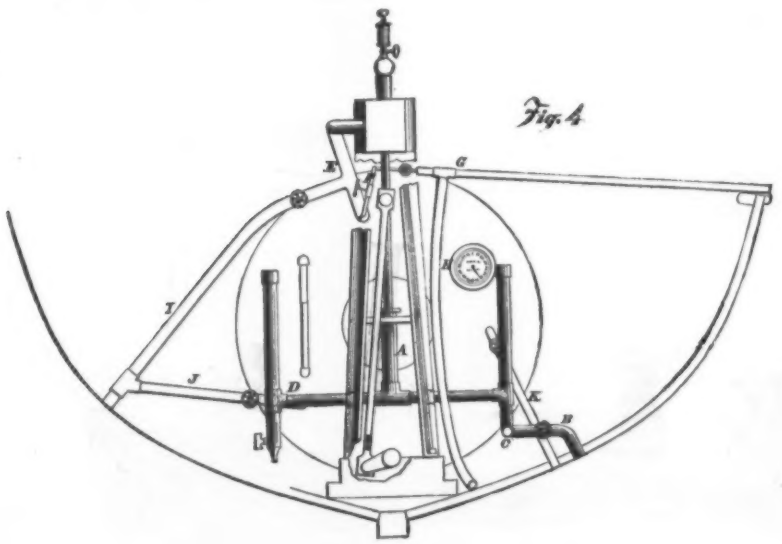


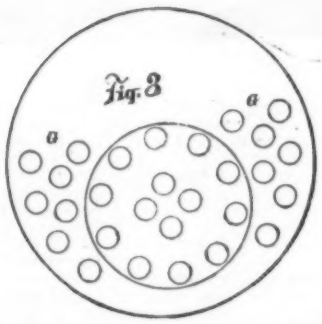
Fig. 1



THE STEAM LAUNCH "FLIRT." DESIGNED BY H. S. MAXIM, M.E.







ENGINE AND BOILER STEAM LAUNCH "FLIRT."

markable energy, making the air thick with spray, but with skillful steering and occasional "slowing," no water was shipped, and her owner was confident he could go anywhere in her.

Parties desiring further information may address "Paddlefast," No. 49 East 28th Street, New York city.

RAISING SUNKEN VESSELS.

*On a Practical Method of Raising Sunken Vessels.**

By LATIMER CLARK, C.E.

THE raising of sunken vessels has been at all times a question of great interest to the maritime world, and the loss of the Vanguard, has recently drawn an unusual amount of public attention to the subject. Having, in conjunction with my partner, Mr. John Standfield, given great consideration to the matter, we have ventured to bring our plans to the notice of the Institution of Naval Architects, in the hope that they may be deemed worthy of their examination, and that their merits or defects may be fully discussed.

The plans which have been proposed for effecting this object are very various, and while many of them are perfectly impracticable, others are marked by great ingenuity. It would be outside the scope of this paper to attempt any detailed mention of them, but there is one characteristic common to nearly all of them, viz., that with few exceptions they effect their object in a makeshift manner, the operations being performed piecemeal. They do not provide, as they ought, for the construction of some complete and powerful apparatus which can, with slight adjustments, be made applicable to vessels of all sizes, sunk in various positions and depth, but they are more usually of such a character that each case has to be specially considered and dealt with; it naturally follows that the apparatus designed to meet one set of conditions is not found suitable for others, and it is, we consider, chiefly from this cause that wreck salvage as a business has never come into existence on a large and profitable scale; moreover, almost all the plans that have been adopted have been dependent on the aid of divers. These can only work in fine weather, and it is necessary that steamers and crews must wait in attendance on them, and remain idle while the operations are being carried out below, and the submarine attachments are being made, much time is wasted, and the cost of such operations becomes very serious and in many cases prohibitory. The depth to which divers can descend and work effectively is, moreover, very limited; and, where masts and rigging are in the way, the occupation becomes a most hazardous one, for which high pay is necessarily demanded; it is true that jointed diving dresses have been devised, with a view to take the pressure wholly or partially off the diver; but, apart from the stiffness of the joints and the difficulty of working effectively in such rigid dresses, the principle of the well-known Bourdon's pressure-gauge must inevitably come into play, and the body or limbs once bent could only be straightened again by great muscular effort, and at considerable depths, not at all.

Very generally, too, the plans proposed involve the passage of chains and ropes beneath the vessel, or the attachment of chains to hawse-holes, masts, and rigging, etc., an operation of much difficulty; and there is also great difficulty in such cases in equalizing the strain on several attachments. Lastly, when air bags are employed, the tendency of the air to expand as the vessel lifts causes it to come to the surface with inconvenient rapidity and dangerous force.

Mr. Standfield and I, having studied the subject *de novo*, have long since arrived at the conclusion that ship-raising should be carried out on a large scale by a single machine capable of raising ships of all sizes, and that it should be large enough and powerful enough to grasp the vessel bodily from the outside without the intervention of ropes or chains, and without the assistance of divers. The idea of thus dealing with a vessel is not new, and it had in fact been previously described by Mr. Joseph Thomas Parlour in 1871, who has recently shown us his plans, which he has however hitherto had no opportunity of putting into practice.

It will be seen from the model exhibited and from the diagrams that the apparatus we employ to carry out our ideas is practically a submarine dock, somewhat resembling an ordinary floating dock inverted. It is sufficiently large to be submerged over the vessel intended to be raised and entirely to cover it. The breadth inside must therefore be greater than that of the vessel, but the length may be either greater or less, according to circumstances.

The two sides of the dock are each constructed in one continuous length and form two hollow box girders; their cross section is triangular as shown at *a a* in the diagrams, the apex being downwards and forming a knife edge intended to rest at the bottom—the two sides are connected together at the top by a number of transverse box girders *b b b* placed at suitable distances apart, adjusted according to the position of the masts or other obstructions on the deck of the vessel. These girders are very firmly attached to the sides by numerous and powerful bolts, allowing them to be shifted laterally, and also allowing the sides of the dock to be placed nearer together or further apart, according to the breadth of the vessel to be lifted—these adjustments are of course effected in harbor before proceeding to the scene of operations.

At the four corners of the dock rise four cylindrical columns of large diameter (say 20 ft. more or less), the tops of which are always considerably above water, even when the dock is submerged over a sunken vessel. These columns rise from the transverse girders at the ends of the dock, which are made of suitable breadth to accommodate them; and they are braced together in pairs and connected by a bridge.

They contain the engines, pumps, and machinery, and to give them greater strength they are, up to a certain height, made double, that is to say, they consist of two concentric cylinders, the space between being divided into cellular compartments

The whole structure is built of hollow riveted ironwork, and when empty is extremely buoyant, the sides alone being more than sufficient to float the whole. When it is desired to submerge the dock over a vessel, water is admitted first into the sides of the dock and subsequently into some of the transverse girders, and if necessary into the vertical cylinders; the dock is thus allowed to sink gradually in the water until only the four vertical columns remain above the surface—the operation is further continued until the dock is sunk over the vessel, either resting upon its deck, or the knife edges of the sides resting upon the ground—as shown in Fig. 3. Assuming for the moment that the vessel is upright and free from any accumulation of sand, it becomes necessary to grip the vessel. This is effected in the following manner: A number of grapnels or curved iron clutches, fitting approximately to the sides of the vessel, are hinged at the top to the sides of the dock along its whole length. They are each 10 ft. or 12 ft. broad, constructed of hollow wrought iron plate, and are of great strength; during the submergence they lie back close against the sides of the dock. Each of these clutches can be thrown forward at pleasure, by the inflation of a large air bag secured to its back and resting behind it against the side of the dock. A single pair of these clutches, situated near the middle of the vessel, is first thrown forward and caused to grip the vessel; a second pair is then similarly brought into bearing, and the remaining pairs in succession; each pair of clutches, as the latter take their grip, is held in position by ratchets and pawls behind in such a manner that the clutches cannot be forced back again; this is to give them additional support when the strain of lifting comes upon them; it will be observed that the curve given to the clutch gives it a secure bearing beneath the bilges of the vessel; at the stem and stern air bags without clutches press up beneath the vessel and afford an additional support; in this condition of things it is evident that the dock and the vessel are firmly united, so as to form practically one structure, and the buoyancy of the bags alone will in many cases be sufficient to cause the whole structure to begin to rise; should they not do so, water is forced out of the cross girders, and if necessary out of the hollow sides, until the vessel rises; as soon as it begins to float it would come entirely to the surface were it not that the four large cylinders as they emerge from the water reduce the buoyancy and so prevent the dock from rising too suddenly.

As the bags approach the surface the external pressure of the water upon them is diminished and their internal pressure is increased; in order to relieve this they are provided with the usual pressure valves, opening outwards and adjusted by springs to such a pressure as is deemed best for gripping the vessel; this pressure can never be exceeded, as the surplus air escapes through the valves into the sides of the dock, or, if its buoyancy is not wanted, into the open water.

The engines and air pumps are of very great power, so as to perform their functions rapidly, and are four in number, situated one in each of the four corner cylinders, and pipes lead from them through the sides to every compartment of the dock; each is of course provided with a pressure indicator, as the pressures are sometimes excessive, amounting in some cases to 70 lbs. or 80 lbs. on the square inch; the pumps are duplicated and so arranged that they can either both work in conjunction or can each work separately under half pressure—that is to say, one can pump into a pressure chamber at 35 lbs. or 40 lbs. pressure, and the other work out of this chamber at full pressure; even in ordinary use a large space is devoted to air chambers, in which a store of air is accumulated under pressure ready for immediate use, so that the grippers, for example, can be closed at a moment's notice.

We will now suppose that instead of the vessel lying in clear water it has sunk into the sand or mud, or become surrounded with sand; on lowering the dock the knife-shaped edges of the sides will rest on the sand in some uneven position, too high to permit of the vessel being properly gripped; in order to afford means for removing this sand the bottom edge of the sides is divided into compartments, and each compartment has a number of holes close to the lower edge; the compartments being full of water, a large reservoir of compressed air is suddenly turned upon the water, which drives it out of the apertures with great violence, stirring up the sand and washing it away, and allowing the dock to settle down to a lower level until it either rests on the bottom or bears on the deck of the vessel, as shown in Figs. 1, 2, 3, and 4. The center pair of clutches is now caused to grip the vessel, as shown in Fig. 3, the sand being driven out before them by a rush of water as just described; a second pair is then caused to grip in the same way, and so on till the whole are secured—the clutches themselves, which are of hollow boiler plate work, have also orifices at their points through which powerful jets of water are forced in order to clear their way through the sand, or if preferred they may be used as sand pumps, water and sand being sucked in in front and discharged behind.

When the vessel does not lie on an even keel the dock has

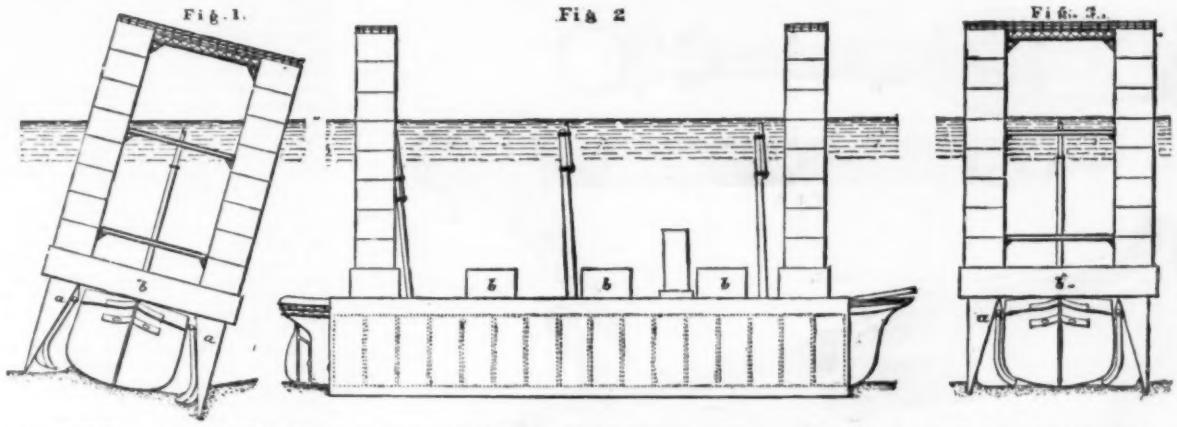
* Paper read before the Institution of Naval Architects.

to be lowered in a slanting position, Fig. 1, by admitting water at one side and not at the other—when passed over the hull of the vessel she has clutched temporarily, and by giving buoyancy to one side only, she is first brought to an even keel and either raised to the surface or gripped a second time in her upright position. The vessel when raised is floated away to a tidal harbor and repaired or broken up. In the case of a vessel with a hole in her sides or bows, such as that in the Vanguard, an attempt would of course be made to fit an air bag directly over the aperture, and as the dock would be furnished with powerful pumps water might be pumped out of her compartments while she was being towed to port.

afloat, any adjustment of width and position may be effected.

I have thus described as briefly as possible the construction of the dock, and will only add in conclusion that owing to its peculiar form its stability is so great that if forced down purposely on to its beam ends it would right itself instantly, and with great power. If sunk over a vessel only the four cylinders would be above water, and from their small area and great strength they would withstand the heaviest storms without danger or injury. In raising a vessel no divers are required and no chains or attachments have to be made; she is supported under the bow and stern as well as under the bilges, the points where the weight of

equally marvelous that the bearings should have been allowed to get into such a condition. It would be interesting to know when the screw of the Thetis was last lifted, and who was responsible for the state of affairs shown by our engravings. We may add that another photograph in our possession shows that the worm employed for turning the engines by hand had been subjected to extremely severe wear, the engines requiring, we understand, enormous power to move at all, a fact which ought to have drawn attention to something being amiss. Altogether, so far as the information at present available enables us to form an opinion, the failure of H. M. S. Thetis is the reverse of creditable to all concerned.—*Engineering.*



CLARK & STANDFIELD'S IMPROVED METHOD OF RAISING SUNKEN VESSELS.

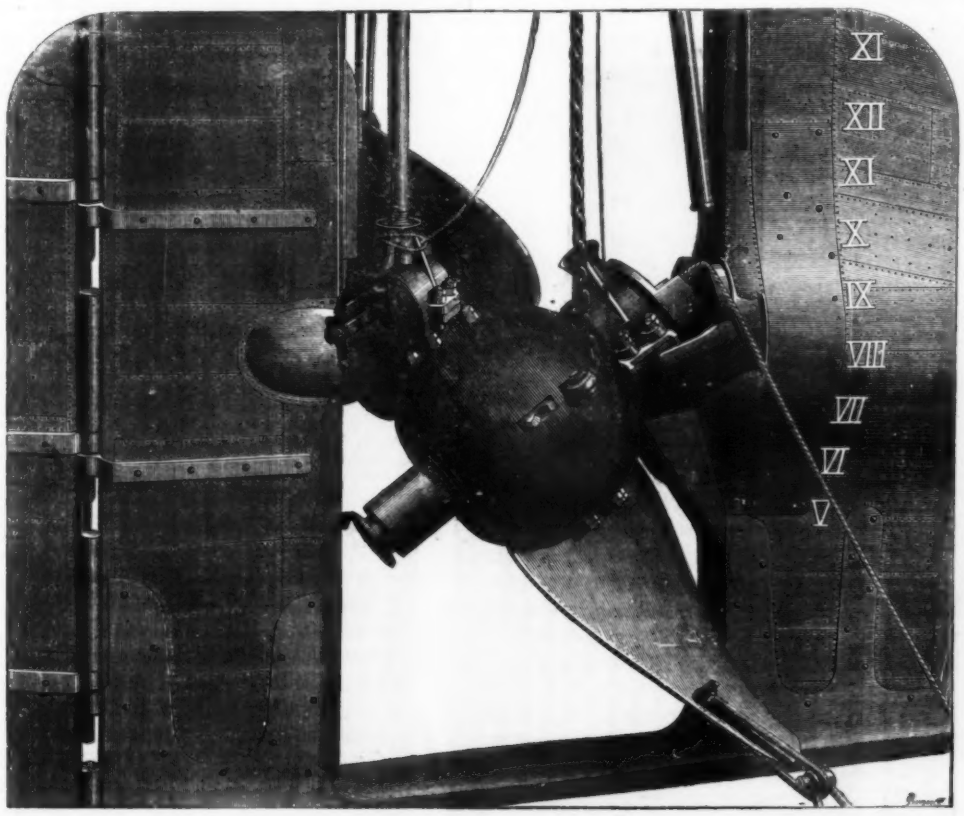
We may now consider the degree of pressure required on the bags to give an effective grip. A vessel drawing 20 ft. of water has, when afloat, an upward pressure of about 10 lbs. per square inch over her whole bottom surface. Disregarding her loss of weight when in water, and assuming that the air bags bear against over one-half her bottom area and support the whole weight, we should require a pressure upon them of about 20 lbs. per square inch to raise her; but this assumes that the powerful framed iron grippers support no portion of her weight, whereas they are strong enough to support the vessel without assistance; the weight is therefore borne partly by the grippers and partly by the upward pressure of the air bags. The bags are made of several layers of stout canvas and vulcanized india rubber and are easily able to withstand a pressure of 30 lbs. or 40 lbs. per square inch, or if inclosed in netting a much higher pressure. They are protected from injury by stout matting or thick rope netting.

The sides of the dock contain a passage running along their whole length, provided with stout glass eyes at inter-

her cargo chiefly rests, and where she is best fitted to withstand the strain, the lift in fact takes place along the whole of her length from stem to stern. The operation under favorable circumstances may be effected in a single tide, and the apparatus ought in average weather to raise at least two ships every week. It is obvious that the depth at which the Vanguard is sunk offers no practical difficulty in the application of the apparatus described; on the contrary, such an apparatus could very well raise vessels sunk at twice that depth. The operation of lifting such a vessel as the Vanguard would probably repay the entire cost, and the salvage value of the property recoverable around the shores of the United Kingdom alone would doubtless be sufficient each year to recoup the value many times over.—*Engineering.*

PROPELLER AND PROPELLER SHAFT OF THE "THETIS."

H. M. S. THETIS was recently disabled whilst in the Mediterranean by the failure of her screw, and had to be



PROPELLER AND PROPELLER SHAFT BEARINGS OF H. M. S. THETIS.

vals, so that the operator, provided with a powerful light held against one of them and looking through the other, can descend and examine any obstructions or see the position of the ship in respect to the dock, and so regulate its descent. By means of these passages one is enabled to get from column to column, and in fact all around the dock without coming to the surface.

In order to adjust the distance asunder of the sides and the position of the top girders, the whole dock is floated on to a framework in harbor, of such a height that the girders rest on the frame at the same time as the sides of the dock rest on the bottom; by unfastening the ends of the girders at opposite sides alternately, and keeping the sides nearly

towed into Malta to be there docked and overhauled. One of our engravings has been prepared from a photograph of the stern of the Thetis taken soon after she was docked at Malta, while the other views have been engraved from photographs of the shaft bearings, etc., taken after their removal from the vessel.

It will be seen from our illustrations that the Thetis was fitted with a lifting screw and that the outer bearing had been allowed to wear completely through, the outer end of the shaft then falling, and the propeller being only prevented from going to the bottom by catching at the stern post. Looking at the photograph, it appears marvelous that the propeller should not have been completely lost, while it is

rent which issues from the hole, is pitted. Also the blades of all the propellers of all transatlantic vessels laid up at the yards of the Messrs. Cramp are, says the *Polytechnic Review*, similarly corroded. The thrust side is never corroded; nor are the blades of coastwise steamers so affected.

THE owners of the Great Eastern are, it is said considering the propriety of converting their vessel into a huge refrigerating chamber for the conveyance of American meat. The trade in meat, which is being developed not only with the United States, but also with Brazil, promises to open a wide field of usefulness—a trade which will generally provide the great vessel with a full load.

PUMP PROPULSION.

A SMALL steamer, called the Alpha, built in Baltimore, and propelled by pumps, lately arrived in New York. The boat is 43 feet long and 7½ tons burden. Amidships is a boiler, and in the place of an engine a No. 7 Knowles pump. The steam furnishes the motive power of the pump, and the pump, it is said, moves the boat through the water at the rate of eight knots per hour. But we presume the velocity here stated is an exaggeration. The water to supply the pump is drawn from the stream in which the boat moves, unless an accident to the hull should occur, when the motive power of the vessel would be drawn from the leaking hold. Four copper pipes, 2¼ inches in diameter, are connected with the pump. The ends of these pipes terminate in heavy brass nozzles five-eighths of an inch across, two opening flush with the stern of the boat four feet below the water-line on either side of the rudder. The other two nozzles open flush with the stem, one each side, about a foot above the keel. With sixty pounds of steam in the boiler the pump makes 180 revolutions per minute, each revolution sending a stream of water forcibly through either the stem or stern nozzles. To go ahead, the water is driven through the stern nozzles, and *vice versa* and so the boat is pushed on.

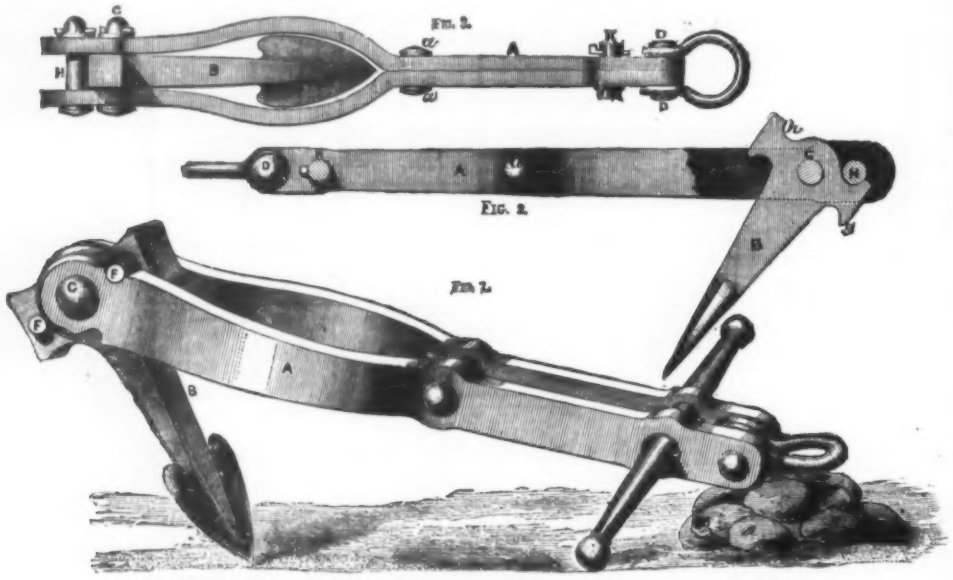
CORROSION OF PROPELLERS.

A CURIOUS fact respecting the corrosion of the cast iron propeller blades of all transatlantic steamers was recently illustrated by the exhibition of a screw blade before the Franklin Institute. The "following" side of the blade was much corroded, but the thrust side not at all. The surface at one part was very deeply pitted, but a line of about an inch and a half from the outer edge was not at all corroded. A circular hole made through the upper center for convenience in shifting, and through which, of course, the water passes, is not corroded in its interior; but the surface of the blade adjacent to this hole, under the line of the cur-

IMPROVED SHIP'S ANCHOR.

FIGS 1, 2, and 3 represent a new style of ship's anchor, recently patented by Mr. G. Tyzack, of Stourbridge, Eng. A is the shank, made in two parts, secured to each other by the pins H *a* K D. The arm with its fluke B is fitted with a T head, *h g*, Fig. 2, which bears on the pin H, as shown. In Fig. 1 two pins, F F, are fixed in the head and act instead of the single pin H, Fig. 1.

The novelty claimed by the inventor consists in the anchor having only one arm, which is reversible, and so arranged that whichever way the anchor falls it finds itself at once in a position to bite. The other chief advantages claimed by the patentee are—that the anchor cannot foul when holding, having no projection above the shank; that it is very snug for handling; occupies a minimum space in stowing; can be readily taken to pieces; possesses unusual strength; and being made without a single weld, and simple in construction, it can be produced at less cost than any other portable or swivel anchor. An anchor similar to one of the engravings has been experimented with to test its biting and holding power, by dragging it over some rough ground by means of a powerful steam winch, when it was found that immediately the steam winch caused the anchor to move, the arm at once penetrated the ground and buried itself immovably. The same anchor was afterwards submitted by the patentee to Lloyd's Committee on Chain and Anchor Proving Machines to be tested to destruction, for the purpose of satisfactorily testing the strength and proportions of the anchor; and after trial it was favored by a report from Lloyd's Committee, dated 22d March, 1877, and signed by Mr. D. G. Lewis, superintendent of Lloyd's Proving House, Netherton, certifying that the anchor, weighing 6 tons 3 cwt. 5 qr., exclusive of stock, had been subjected at Lloyd's machine, under his superintendence, to the following strains, viz.: In the first instance to the Admiralty test, 9 tons 1 cwt. 1 qr., then to 13, 17, 21, 25, 26, and finally to 32 tons, at which strain—250 per cent. overproof—it was broken to destruction.—*Engineer.*



IMPROVED SHIP'S ANCHOR. BY G. TYZACK.

ON STEAM BOILERS AND ENGINES FOR HIGH PRESSURES.*

By MR. LOFTUS PERKINS, London.

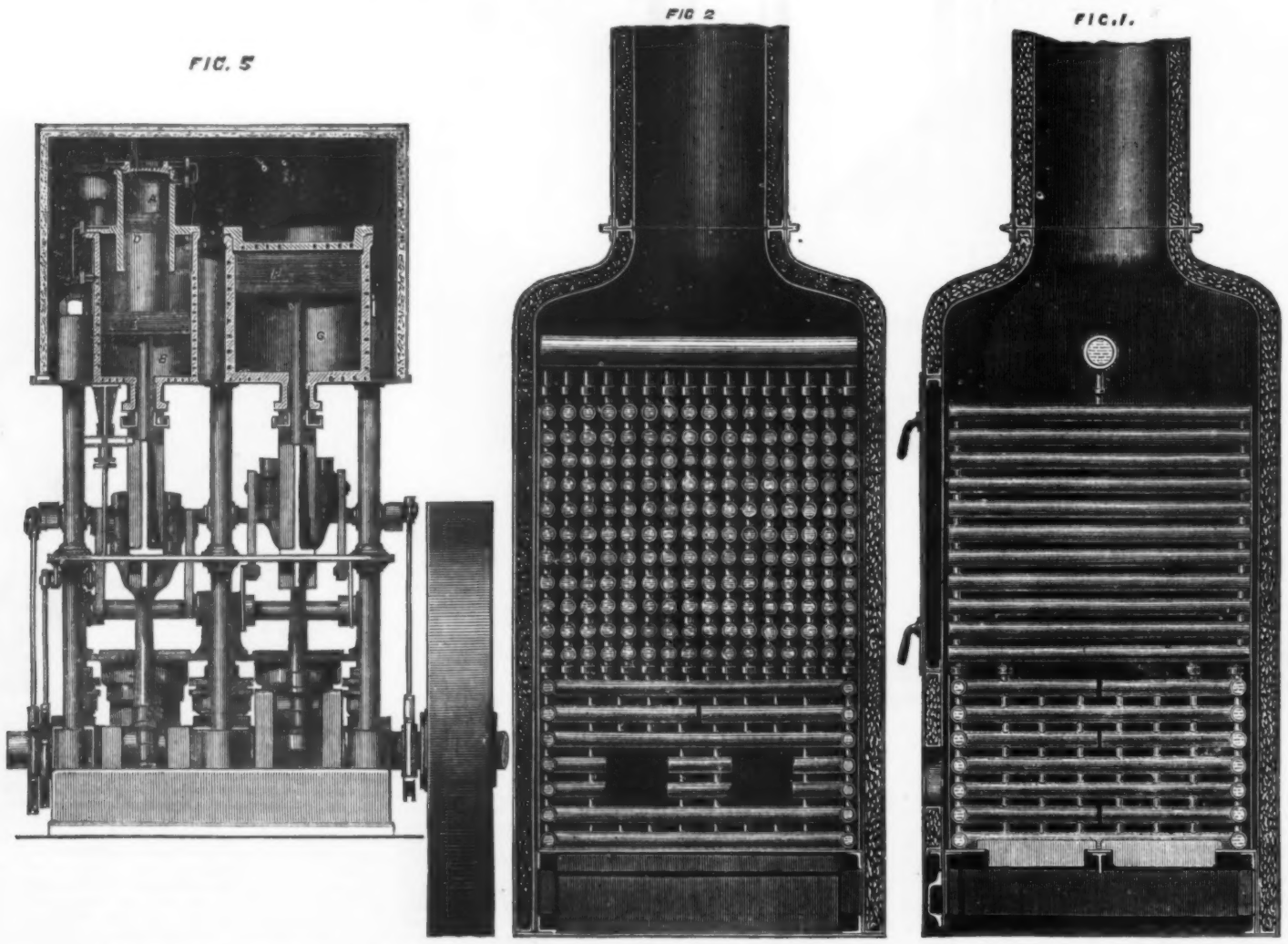
THE object of this paper is to bring before the Institution plans for generating high-pressure steam, say from 250 lbs. to 1,000 lbs. per square inch, and working it with great expansion and perfect safety in conjunction with simplicity and durability. Sixteen years ago the author, conjointly with Professor Williamson, read a paper on this subject at a meeting of this Institution in 1861. The engine and boiler then described have been in use ever since, and recently became the property of a gentleman who for several years has had another boiler and engine on the same system at work. The boiler and engine of 1861 are to be re-erected at the new works of the Sub-Wealden Gypsum Co., at Battle, near Hastings, and are to form part of a steam plant consisting of three sets of boilers, engines, etc., on this system. Since 1861 many improvements have been effected, and are embodied in the engines recently constructed and illustrated in the accompanying diagrams.

In generating steam of the high pressure required to realize a fuller benefit of expansion, it has previously been found impossible to combine in the boiler great strength and safety with durability: if the former are secured, by reducing the internal dimensions and capacity of the boiler, the impurities passed in are fatal to the latter. In working a marine engine which was destined to use the water distilled from the sea, the author found that, although extreme care was taken to separate all the impurities from it before it was introduced into the boiler, the internal surfaces were in the course of time seriously injured. In the same manner, ordinary marine boilers using surface condensation have been injured when there has been an insufficient supply of sea water to form a protecting scale on the exposed internal surfaces. This led the author to seek for a remedy, which he succeeded in discovering, and adopted with absolute success. This was the use of nothing but fresh water, or distilled fresh water in the boiler, used over and over again, without any admixture of sea water or the products of sea water, and this was easily accomplished, as the machinery in question had been designed to avoid any leak whatever, and the amount of waste that did take place from glands, etc., was so small in quantity, that no practical inconvenience was found in providing the small supply of fresh water required to make good the waste that did occur.

The means taken to secure the soundness of all the joints and parts of the machinery were the same as those which had previously proved successful in the manufacture of the high pressure heating apparatus which the author and his firm have been making upwards of forty-five years, and which has continued to work with the same water with which it was originally charged, without any destructive effect on the internal surfaces. Many sets of this heating apparatus have been working forty years without decay; and some specimens of tubes from the boiler that was described in the former paper in 1861, which were cut out of this boiler for the Admiralty Boiler Committee in 1874, were found to be in such a remarkably good state of preservation that the Committee made a special report on the system, which was laid before Parliament; and the specimens referred to are now shown on the table by the kind permission of the Committee. The Committee examined the condition of the boiler and cylinders of the engine at the writer's works, which were opened for the purpose in the presence of the Committee; and found the tubes of the boiler in a remarkably good state of preservation after having been in use nearly thirteen years, and the piston packing and valve rings made of the special metal were found in excellent condition after eighteen months' working without lubrication since last examined.

The possibility of using water which did not injure the internal surface of the boiler enabled the author to design the boiler on a system that combines maximum strength and safety. The diagrams, Figs. 1 and 2, show the construction of the boiler. The horizontal tubes are 2½ in. internal and 3 in. external diameter, excepting the steam collecting tube, which is 4 in. internal and 5½ in. external diameter. The

* Institution of Mechanical Engineers.



HIGH PRESSURE STEAM ENGINE AND BOILER. DESIGNED BY LOFTUS PERKINS.

horizontal tubes are welded up at each end ½ in. thick, and connected by small vertical tube of ⅛ in. internal and 1 5/16 in. external diameter. The fire-box is formed of tubes bent into a rectangular shape, placed 1¼ in. apart, and connected by numerous small vertical tubes ⅞ in. diameter. The body of the boiler is made of a number of vertical sections, composed each of eleven tubes, connected at each end by a vertical one; these sections are connected at both ends by a vertical tube to the top ring of the fire-box, and by another to the steam collecting tube. The whole of the boiler is surrounded by a double casing of thin sheet iron, filled up with vegetable black to avoid loss of heat. Every tube is separately proved by hydraulic pressure to 4,000 lbs. per square inch, and the boiler in its complete state to 2,000 lbs., this pressure remaining in for some hours without showing any signs of leakage. Experience of a very extensive character has proved that this construction of boiler can be worked safely, with great regularity, and without priming, and that the steam produced is remarkable for its freedom from moisture. The area through the vertical connecting tubes is found ample for allowing of the free escape of the steam, and for the prevention of injury from overheating of the tubes in contact with the flame. Injury arising from a prolonged stoppage of the feed supply is a casualty to which all boilers are liable, but with this construction of boiler the small capacity of the sections reduces to a minimum any danger arising from such injury, and facilitates rapidity of repair.

In the diagram, Fig. 5, is shown the arrangement for using the high-pressure steam in the engine. The engine has three cylinders, the first, A, is a single-acting high-pressure cylinder, and the second, B, also a single-acting cylinder, four times the capacity of the first; these two cylinders are bolted together in the same straight line, and have a common piston rod. The third cylinder, C, is double-acting, four times the capacity of the second, and its piston rod is connected to a crank at right angles with the other crank.

Having safely generated steam of high pressure, at say 340 lbs. per square inch, a serious difficulty has to be overcome in using it, from the high temperature affecting the lubrication of the pistons and the packing of the glands. This difficulty

FIG. 4

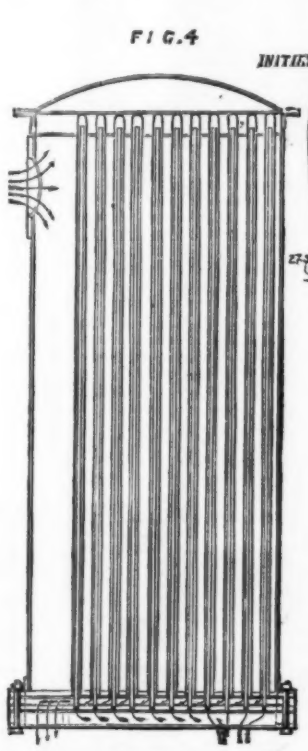


FIG. 6

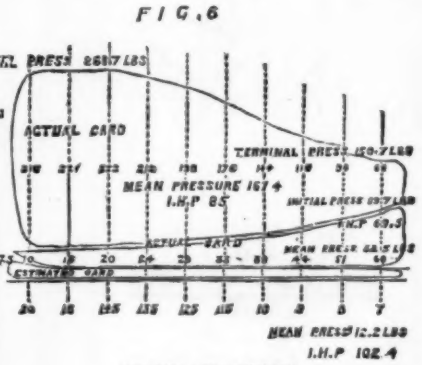
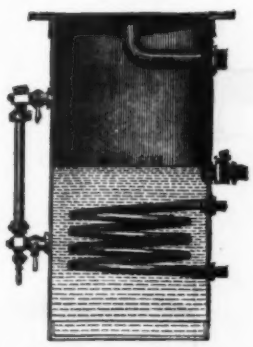


FIG. 5



HIGH PRESSURE STEAM ENGINE AND BOILER.

ing rings. This metal for piston packing rings is composed of five parts tin and fifteen parts copper, and has since been used by several other makers for ordinary engines with great success. When this metal is used, no oil or grease is required to lubricate the cylinders—a great advantage, particularly where the engines are fitted with surface condensers.

The high-pressure pistons in the steamers Atacama and Coquimbo, of the Pacific Steam Navigation Company, were fitted with these packing rings, and it was reported by the superintendent engineer that the cylinders, which were previously rough and slightly grooved, were in the course of two or three voyages, or about 10,000 miles run, brought up to a beautiful smooth surface, and had since kept in capital order, giving no trouble whatever. After having once been brought up to a smooth working surface, the packing rings did not wear the cylinders; the wear of the rings was also very slight, and the friction greatly reduced, and one third of the lubrication necessary for cast iron rings was found sufficient. In the torpedo vessels made for the French Government, Messrs. Thornycroft found these packing rings for the engine pistons a great advantage, as there was no chance of the cylinders being scored; and they were enabled to run the two hours' trial easily, at the high speed of about 430 revolutions per minute, without using any oil or grease in the cylinders. In an engine at the Dorking Gray Stone Lime Co.'s Works, the manager reported, after a two and a half years' use of these packing rings for the piston, that they required no grease of any kind, and worked the cylinders to a polished face and needed no looking to until worn out; a set of rings lasted about 100 days, working at the usual high steam pressure of 400 lbs. per square inch.

The diagram, Fig. 4, shows the surface condenser used; it is constructed of a number of vertical tubes in such a manner as to be absolutely tight, so as to insure that the condensing water inside the tubes shall not mix with the water from the condensed steam outside them. The tubes are ⅝ in. internal and 1 1/16 external diameter, and welded up at the top end and fixed securely in a tube plate at the bottom. These tubes are fitted with internal tubes, open at both ends, which are fixed in a division plate at the bottom, in order to cause

the author has succeeded in overcoming by introducing the high-pressure steam into the upper end of the first cylinder, where there is no gland, and where the piston is formed so as to require no lubricating material. The steam is cut off at about half stroke in this cylinder, and when it is admitted for the return stroke into the bottom of the second cylinder, of four times the area, the temperature is so much reduced as to cause no difficulty when brought into contact with the piston rod gland. From the bottom of the second cylinder the steam expands into the top of the same cylinder, D, which is of larger capacity than the bottom, and serves as a chamber, and is in direct communication with the valve box of the third cylinder; this last is double-acting, and is arranged to cut off at about a quarter stroke, and at the termination of the stroke exhausts into the condenser, with a total expansion of about thirty-two times. All the cylinders are jacketed with wrought iron tubes, as shown in the diagrams, which are cast in the metal, and supplied with steam direct from the boiler, the condensed water from the jackets being conveyed to the hot well. The whole of the cylinders and valve-boxes, etc., are inclosed with a double case of thin sheet iron, filled in with vegetable black to prevent the escape of heat, and at the same time to maintain all the parts at a high temperature.

In working these high pressures with great expansion the ordinary mode of packing the pistons was found unsatisfactory, and to overcome the difficulty the compound piston was devised. The prevalent scoring and cutting of engine cylinders was effectually remedied by the discovery of the compound metal, of which the packing rings are made, which requires no lubricating material. Many cylinders fitted with piston rings made of this metal have been several years at work, and have been often examined, the cylinders showing no signs of wear, the wear taking place on the rings only, which may be easily and inexpensively renewed as required; and experience has proved that, with these pistons, the longer an engine is worked the more perfect does the surface of the cylinders become, and the less wear results to the packing.

the condensing water to circulate to their extreme ends, the course of the circulating water being shown on the drawing by arrows.

Fig. 3 shows a small still, worked by a steam coil, which is used to distill water for replenishing any small waste that may take place in the feed supply. A duplicate apparatus forms part of the ordinary equipment of a sea-going vessel, to furnish steam from sea water for blowing the steam whistle, cooking, supplying distilled water for use of passengers and crew, and for all other purposes where distilled water is required.

In designing the machinery described, provision is made for passing any waste steam from the safety valve, etc., into the surface condenser, and the great strength of the boilers allows a margin of 100 lbs. per square inch or more to exist between the load on the safety valves and the pressure required to work the engines. When this system is fully carried out in steamships, he would deem it quite safe, and more than ample, for making good the waste of water from all sources, to provide, beyond the waste of water from the boilers, a supply of fresh water in the proportion of ten gallons per twenty-four hours per 100 indicated horse power. As an instance of the practical feasibility of carrying out the system of machinery that has been described, it may be stated that a boiler containing only 300 gallons, and an engine working at 250 lbs. pressure and 250 indicated horse power, were worked night and day continuously thirteen days—one Sunday excepted—without requiring any addition to make good the waste of working, nor at the end of the trial was there any appreciable difference in the water level of the boiler.

In the indicator diagrams, Fig. 6, the two upper diagrams are taken from the working of a pair of marine engines on this plan of 70 nominal horse power, and the coal consumed averaged 1·62 lb. per indicated horse power per hour. In this case there was no vacuum and no low pressure cylinder, and the terminal pressure was 21 lbs. per square inch above the atmosphere; the boiler pressure was 300 lbs. per inch. With the addition of a low pressure cylinder and a vacuum, the author considers that it may safely be estimated that this system, properly carried out, will realize an average duty of one horse power for each pound of coal per hour.—*Engineer.*

BICYCLING.

THE largest meeting of bicycle riders which has ever been held assembled on May 25th at Hampton Court, Eng. On their bicycles, closely packed and stationary, the drivers extended for a mile and a quarter on the Kingston Road, and numbered between 1,500 to 2,000. It is about ten years since the first wooden bicycle was made in England, and only seven years since the iron machines with rubber tire, spider wheels, and an improved felly, were first made by the Coventry Machinists Company. On Saturday, however, all of the machines displayed were of this type, and made of iron or steel, with perhaps a single exception. That was a wooden bicycle ridden by a bicyclist unattached, which was received with astonishment and laughter. In the six or seven years during which the new bicycles have been made it is estimated that 30,000 of them have passed into the possession of the public in England. Many have been exported to the colonies. The one Coventry company already mentioned turn out 130 machines a week, and in the town of Coventry alone £2,000 a week are paid in wages to operatives skilled in the manufacture. This new industry has in Coventry taken the place of the decaying trades in watches and ribbons. Bicycles are also made, though not on so large a scale by any one firm, in London. Those for ordinary wear and tear are of hollow iron with spokes made of iron wire drawn through a charcoal fire. A lighter and more brittle sort are manufactured of steel. Great speed is obtained with the new machine. Of twenty-six riders who traveled recently from Bath to London the first came in a little more than eight hours. At Wolverhampton, lately, Mr. Keen, in a ride of five miles, traveled one of his miles in two minutes and forty-four seconds. In a country with good roads like our own, the bicycle-rider, traveling very swiftly and with perfect silence, might be very useful in war as a scout and dispatch bearer. Postmen have already used the machine, and it might be useful to the police. It is the silence of the bicycle that constitutes its chief danger to pedestrians and horsemen in time of peace, and the expediency of obliging each bicycle to bear a bell, like the small bells which tinkle in the harness of horses in many foreign countries, has been seriously considered.

HORSESHOEING.

AT the recent Bath (Eng.) Agricultura. and Mechanical Show for the shoeing competitions there were thirty-two entries.

The enclosures contained five forges, so that only that number could be at work at one time. The competitors drew numbers for the order of commencing, the numbers one to five going on first, numbers six, etc., following, and taking vacancies as they occurred. Each competitor had to light his own fire, make his nails, and provide his tools; receiving no help from the striker, except to assist in blowing. Five nails only were allowed to each shoe, which has to be made as nearly as possible to Miles' patent. The foot must not be cut, either in the sole or frog, but each shoe made to fit the inequalities of the foot. Only one shoe to be put on by each competitor. The start was made at 11.27 A. M., and Marchant came out at 12.5 P. M., having done his work in 38 minutes. Very few of the competitors did it in less time, the winning men being timed: Watts, 1.44 to 2.24 P. M.; Williams, 2.32 to 3.18; and Pearce from 12.17 to 1.16. As competitions these times may seem rather long, but the work was done under many disadvantages, a high wind and a driving thick rain which lasted the whole day, and made it difficult to obtain heats with any rapidity.

ANOTHER ATLANTIC CABLE.

THE steamship Hibernia is now engaged in the attempt to raise and repair the 18 5 cable, belonging to the Anglo-American Company, which has not been in operation for some years, and should this attempt be successful, as it is confidently expected that it will be, another cable will be added to those now in use at a comparatively small expense.

Experience has proved, says the *Journal of the Telegraph*, that the existing rates for Atlantic cable telegraphing are as low as can be made profitable, and any further permanent reduction cannot reasonably be expected, until the capacity of long submarine cables for the transmission of signals can be materially increased. It is in this direction that efforts should be directed, and not to the multiplication of cables.

AN IMPROVED SQUEEZER.

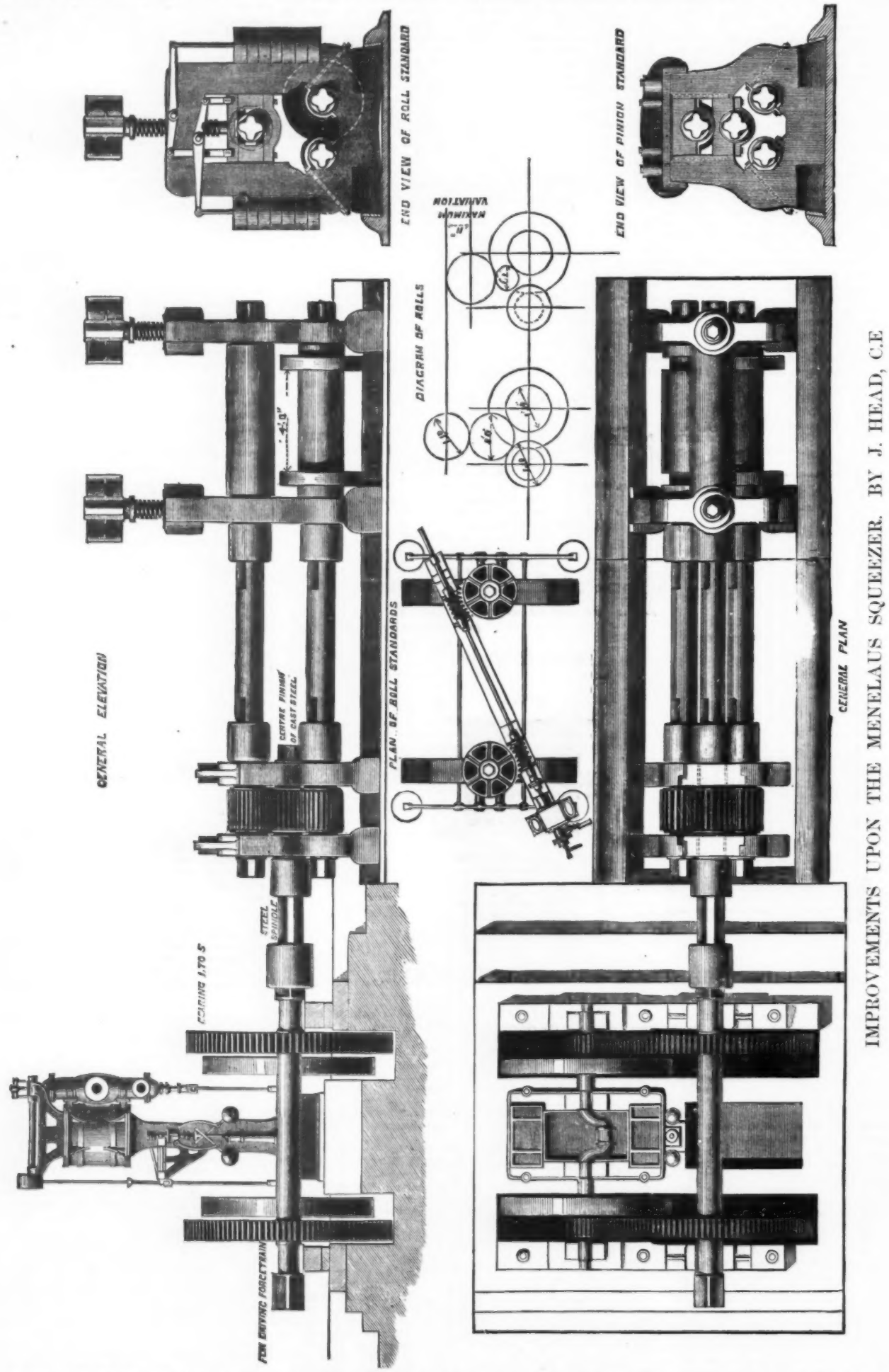
By MR. JEREMIAH HEAD, M.I.C.E.

WHEN, many years ago, Mr. W. Menelaus, of Dowlais, was experimenting with his rotary puddling furnace, he gave considerable attention also to the question of how best to consolidate and clear of cinder the large masses of crude wrought iron which were likely to be produced. Having had great experience in squeezing, as then performed by the Jerry Brown Squeezer, he naturally inclined toward dealing with the iron in that way rather than by hammering. His puddling furnace not being, as he candidly informs us, a commercial success, he did not go so far as to construct a squeezer, but still he matured to a great extent his ideas as to what it should be, and made a wooden model embodying these. This model he exhibited at the Middlesbrough meeting of the Iron and Steel Institute. Since that time Mr. Danks' squeezer, which is very different in many respects, has been adopted at certain ironworks, and with fairly satisfactory results. Mr. Price, of Woolwich, also has made some valuable experiments to determine the best form of squeezer, and these are understood to be still in progress. Other engineers have been and are at work in the same direction. Among these the writer has given the subject some attention, resulting in the design illustrated at page 358, which was brought before the Cleveland Institution of Engineers at their last meeting. The leading principles of Mr. Menelaus' squeezer have been adhered to, but the details as illustrated are new. The engravings show a general side elevation of this squeezer, a plan, an end view of the pinion standards, of the roll standards, the latter in plan a section through the squeezing rolls when the ball is at its maximum diameter of 2 ft., and one when at its minimum diameter of 1 ft. 1 in.

The squeezer proper consists essentially of three rolls, two side by side, with a rotary motion only, and the third above, having also a vertical travel of at least 12 in. One of

the lower rolls has a collar, and the other grooves to suit. The distance between the collars determines the length of the bloom, and the final position of the top roll determines its diameter. The rolls illustrated are suited to blooms weighing about 15 cwt.; but longer or shorter rolls can be introduced for greater or less weights. The upper roll is rather overbalanced, so as to keep it always up against the screws. The chocks containing its bearings are hung on bolts through which two flat bars on edge are threaded. shaft, and driven by the quadruple single-acting engine, as shown. The arrangement for working screws by power was described fully in the "Proceedings" of the Cleveland Institution of Engineers for December, 1876. Since that time it has been put to work in the forge train at Newport Rolling Mills, with complete success. It can be worked by a boy, or by the roller himself. Of the lower rolls, the grooved one is to be of steel to prevent danger of breaking at the grooves. The depth of the collars in the fellow roll central pinion of steel. The length of the connecting spindles, and consequently the space occupied by the train, is determined by the amount of deviation which the upper one can be allowed to make with the horizontal.

In the illustration the angle of deviation does not exceed what is now regularly at work at the above-named mills. The engine shown as driving the squeezer is an inverted one with variable expansion, steam jacketed, and carefully balanced throughout for a high speed. It has a 20 in. cylin-



IMPROVEMENTS UPON THE MENELAUS SQUEEZER. BY J. HEAD, C.E

The ends of these are secured by links to four levers pivoted to the standards. Balance-weights are strung upon rods at the other ends of these levers until the required counterpoise is obtained. This forms a very compact arrangement, and is free from the objections which attach to placing the balance-weights overhead or in pits beneath. The top roll is lowered and raised by means of the right and left hand worm wheels geared into the worms upon the diagonal is somewhat greater than half the diameter of the finished bloom, so as to prevent any central projection being left. The piece to be squeezed is tipped in from a bogie, and the collared roll will itself deliver it forth upon another bogie on the top roll being raised and a crowbar being inserted between the grooved roll and the bloom. The three rolls are driven through ordinary coupling boxes and spindles by three pinions, which, in their turn, are all driven by a small der by 20 in. stroke, and is intended to run at 120 revolutions. The gearing is 1 to 5, giving 24 revolutions for the train. At the other end of the second motion shaft is a provision for attaching a blooming mill or ordinary forge train. The engine does not reverse, as this is considered unnecessary with steam-worked roll screws, for by means of them the pressure can at any time be removed from the bloom under treatment.—*Engineer.*

SPONTANEOUS COMBUSTION.

By CHARLES W. VINCENT, F.R.S.E., F.C.S.*

STRICTLY speaking, there is no such phenomenon as spontaneous combustion. The inflammation of various organic and inorganic substances, without the immediate contact of any ignited matter, which has given rise to the term, is, nevertheless, as certainly the result of some direct act or acts which can be accurately traced, as is the firing of a lucifer match when struck on a rough surface.

The discovery of what the active agents are, and the circumstances under which they occasion visible ignition, has long been the subject of research, and, one by one, they have been so fully investigated that there should be little difficulty in at once assigning the specific cause to every species of "spontaneous combustion." It is, nevertheless, so difficult to shake off the trammels of incorrect observation, and theory founded thereon, that there are even now many cases in which combustible substances catch fire, in spite of great precaution having been taken to prevent such catastrophes, and this because care and attention has been wholly directed to prevent something which is not likely to take place, and no thought has been given to that phenomenon upon which all combustion, as it is commonly understood, depends, *i. e.*, the combination of the components of the combustible body with oxygen.

It is not here intended to treat of fires arising from friction of machinery; lighting of explosive gases or vapors; the action of the sun's rays through unintentionally disposed lenses, such as may be formed by glass globes filled with water or knots in a pane of glass; firing of disseminated flour, or cotton, etc.; but to examine some of those cases when starting with the combustible at the ordinary temperature, it gradually becomes hotter and hotter, and at last takes fire without, to the unscientific observer, any apparent reason for its so doing.

Many animal and vegetable substances heaped together in a large mass, when neither too wet nor too dry, are liable to take fire by the heat produced by their own decomposition. Haystacks often afford examples of this. Heaps of any dry fibrous vegetable material, or of dry wool, cotton, cloth, calico, paper, sawdust, etc., when smeared with grease, oily matter, or particularly a drying oil, such as linseed, and left undisturbed in a warm dry place, are tolerably sure to be consumed by fire. Coal piled in quantity, and left too long in one place, or confined in great bulk in the hold of a ship, on a long voyage, frequently behaves in a similar way. A comparison of the conditions under which the spontaneous combustion of these three classes of bodies, viz.: damp organic matter, dry oily organic matter, coal—takes place, may be useful by suggesting the means of preventing them from happening.

HEAT.—WHAT IT IS AND HOW PRODUCED.

In a rough way, we may describe heat as being the effect of a blow upon an immovable body. A nail on an anvil struck by a hammer becomes hot, the visible motion of the hammer is converted into the invisible "mode of motion" (to use Dr. Tyndall's happy phrase), heat. If the nail were perfectly free to move, the blow would produce no heat. A wave of the hand in the air, though made with the exertion of the utmost muscular power, produces no sensible heat, because the air is set in motion. The same force applied to strike a blow upon enclosed air—as, for instance, in the fire syringe, or in a force pump—produces a very sensible quantity of heat. The air is less free to move, and the heat produced is in proportion to the destruction of its motion. Were we to follow out, to its fullest extent, the effect of the blow on the free air, we should find that heat resulted here also; each particle of air struck drives before it the particles surrounding it. But, though air is very mobile, it is not perfectly so; amongst other restraining agencies, it is somewhat held together by the force of gravitation. The circle of motion, though extensive, still has its limits; the full force of the blow received is, therefore, not imparted to the surrounding molecules, and the amount of force which thus disappears is manifested as heat, but the concussions, being feeble and spread over a large space, are imperceptible to our senses. The resulting heat is, nevertheless, quite as great in quantity as when the air is struck in a chamber with rigid boundaries.

Imagine a vessel devoid of air, to which air is suddenly admitted; the air will rush in, will strike against the side of the vessel, its motion will be arrested; the force which produced that motion cannot be destroyed, it is converted into heat.

Freshly burnt charcoal is as a vacuous chamber to many gases, since it has the power to condense within itself many times its volume of some of them. The falling in of these gases and their condensation is a succession of blows followed by a stoppage of motion, heat is produced, and in some cases makes its presence unpleasantly manifest. Condensation of a gas, by whatever means, implies application of force followed by cessation of visible motion; every such condensation must, therefore, produce heat.

Freshly reduced iron is in a similar way vacuous to oxygen. If the iron is so finely divided as to afford room for the gas to strike a sufficient number of blows at it, the clashing of the atoms produces enough heat to raise the temperature to that at which chemical combination of the iron and oxygen can take place, and this with so much rapidity that the metal takes fire and burns spontaneously.

In the instances already given, heat is clearly the product of physical action. The heat produced by chemical combination is also the result of blows given and received. The stroke of a hammer concentrates and expands a certain amount of force in one blow; friction expends the same amount of force in producing a succession of blows less in intensity; in condensation by charcoal the gas expends force in producing a succession of blows still feeble, but infinitely more numerous. When a substance burns in air, the action which takes place is of precisely the same character, the blows being, however, indefinitely multiplied.

The combustible is first heated to a particular temperature, varying in different substances, called its point of ignition; to continue burning it must continue at this temperature; if cooled below this point the combustion would not be maintained. The initial temperature is that at which the particles of the bodies uniting receive sufficient momentum, when the molecules of oxygen and the combustible rush together.

At the moment of combination, their motion is checked and converted into heat and light. The greater the rapidity of the action, the more intense is the heat, and the less its duration, the slower the action the more feeble is the heat, and the greater its duration. The quantity is in each case precisely the same.

* Read before the Society of Arts, London.

This meeting together of the atoms of bodies is an expenditure of force; a combustible in burning loses something; the chemists of the past century termed it "phlogiston," those of to-day "energy." The heat produced is something more than that due to the condensation in volume; this surplus is the heat due to the loss of energy.

Heat and energy are equivalent values. All the elementary bodies have a specific power of performing work, if this power is lessened, as it is when they enter into combination with each other; it is lessened by the expenditure of part of their power for doing work, and heat results. The combinations so formed may be broken up and reconstituted by the accession of some element, or combination of elements, whose power of working is not exhausted, and again heat may be evolved, but at last a point is reached when the constituents of a body have lost all power of motion and then no further change can take place till they are torn asunder, and their energy restored. This can be done by heat; given a sufficient amount of heat, there is no compound whose constituents are so tightly bound together but that they would fly asunder.

HEAT OF DISRUPTION AND OF COMBINATION.

The heat developed by the disruption of any compound substance capable of combustion is exactly equivalent to the amount of heat absorbed in its construction. The heat developed by the combination of elements is exactly equal to the amount of heat required to tear them apart if once united, and no change of constitution of any substance can take place without a certain amount of heat being either absorbed or evolved. If the substance undergoing this change were formed by the expenditure of a large amount of heat, and is passing into combinations which can be formed by the expenditure of a less amount of heat, then heat is evolved; and if this change of state takes place with rapidity, incandescence ensues. If, on the other hand, during the formation of the compound, heat was evolved, then, in order to bring its components into their original state, the same amount of heat must be restored which they parted with when they entered into combination.

There is a powerful factor which can restore to many burnt (that is combined) elements their original working power, by enabling them to absorb gradually, and by slow degrees, the amount of heat expended in their combinations; this is vegetable life. The seed, the plant, the tree, derive all their sustenance from tightly combined elements, which they combine to a more complex, but a more loosely held together state; in point of fact they bring them more nearly to their elementary condition. Plants do this by absorbing the radiant heat of the sun, and by some incomprehensible action of that mysterious power, "life," bringing it to bear upon the inert compounds in the air and the soil.

So long as a plant is living, the heat which falls upon it, if not so great in intensity as to be incompatible with the life of the organism, is absorbed and stored up in the complex, yet feebly combined, substances which form woody fiber, starch, the vegetable juices, etc.

Walking on a midsummer evening beside a grove of trees which has been exposed all day to the glare of the sun, no heat is felt; placing the hand on the trunks of the trees, or on the leaves, they are found to be of the same temperature as the air; the heat has all been absorbed; but touch a dead trunk which has been exposed to the same sun, and, though it has been some time shaded, it will be found to be hot: the heat which fell upon it is now radiating back into space. At the foot of Drayton-park, Highbury, is a crescent of houses upon which the sun falls for a great part of the day; on setting oneself in the focal point of the crescent some time after the sun has gone down, the concentrated rays of heat make the position conspicuously hotter than the rest of the street.

Dead or mineral matter is incompetent to store up the solar heat, or in any way to make it available for chemical decomposition. The work of the sun, unassisted by life, is purely mechanical. A vegetable whilst alive eagerly absorbs heat, using it for "unburning" burnt matter, but so soon as the life has departed, the dead body appears as eager to part with the heat it had gathered; the elements composing its structure are, as it were, rejoicing in their new powers, and are as eager in their turn to enter into more fixed states, in doing which they will part with the heat lately bestowed upon them.

SPONTANEOUS COMBUSTION.

It is for this reason that substances of vegetable origin are liable to spontaneous combustion. From the moment that life is extinct, decay (which is really only another term for combustion) sets in, carbonic acid, water, etc., are evolved, the plant crumbles into a blackish brown mould, and is ultimately entirely destroyed. In the course of this change, the whole of the heat which had been collected by the plant is dissipated. It need not, therefore, be a matter of surprise that bodies containing so much bound up heat as do vegetable fibres of all kinds, more particularly hay, cotton, etc., coal of all kinds, oily rags, greasy sawdust, varnish rags used by painters and polishers, the waste at railway lamp stores, etc., should be particularly liable to take fire when stored in bulk.

Spontaneous combustion of these substances can only take place when they are so packed that small increments of heat may be stored up. If they are freely exposed to the air, the heat evolving action which goes on with it may be increased rapidly; but, as when the hand is waved in mobile air, the infinitesimal blows are free to rebound and react over so large a space that their effect is dissipated. But when their striking space is limited they act like the struck air enclosed in the fire syringe, their heat motion is intensified by concentration, and ultimately throws the whole mass into such commotion that the moving power of the molecules is manifested as light as well as heat.

But there must be a beginning to this heat motion. Oiled rags and bodies of that kind derive the initial movement from the oxidation of the oil. Perfectly dry vegetable fibre at ordinary temperatures oxidises extremely slowly, it is practically indestructible by atmospheric oxidation. Mummy cloths possess much strength after after the lapse of two to three thousand years. Oils, however, are formed at the expense of a still larger amount of heat than vegetable fibre, the elements comprising them are combined much more loosely, and they are consequently ready to form more stable compounds, and release their bound up heat on very slender provocation. Oils absorb oxygen with great avidity, becoming viscid, and, in the case of drying oils, solid. In doing this they give out heat, which is due partly to the condensation of the oxygen, and partly to the carbon and hydrogen of the oil having by combination with the gas lost part of their energy, in fact they have been partially burnt.

In a heap of oiled rags, greasy sawdust, or matters of that kind, air, though not excluded, has only limited access to the center, the heat of oxidation is not there carried off by convection currents; and though not at first great, goes on increasing, because it is surrounded by barriers of non-conductors, *i.e.*, bodies incapable of transmitting the heat motion, and so spreading it over a larger area, until at length it reaches a temperature of about 323° C., when the oil takes fire, and speedily fires the whole mass of which it is a part. The combustion being caused by absorption of oxygen, it is sufficient to exclude the air from the oily materials in use in factories, to effectually prevent their becoming so hot as to take fire. To revert to our parallel, the oils are vacuous to oxygen, absorb it with great rapidity, become hot, and the finely divided vegetable fibers become sufficiently hot to enter into combination with the oxygen on their own account.

SPONTANEOUS FIRING OF HAY STACKS.

In the spontaneous firing of hay stacks, there is no oil to act as an absorber of oxygen, and thus to raise the temperature to that point at which the mutual action of the fibre and gas can take place. Here water is the active agent, though not in the sense in which it is commonly supposed to operate.

It was formerly held that plants underwent decomposition by direct absorption of oxygen from the air, and that the effect of water in promoting the action was to soften the tissues, and allow free access of the air to fresh surfaces, as those acted upon fell away.

Thoroughly dry wood and thoroughly dry hay are safe from destruction by fermentation, decomposition, or "eremacausis," as it is termed somewhat indifferently by various writers. But add water to the woody fibre, and the change takes place with greater or less rapidity, occurring most rapidly in young, spongy plants, which admit the air freely, and contain a good deal of albuminous matter more slowly in slow growing hard woods.

Fermentation produces heat, and, if the heat is shut in by non-conducting matter, as it is in a haystack, it will, under favorable circumstance, accumulate to such an extent as to cause the hay to take fire; and as fermentation cannot happen unless moisture is present, the water is, therefore, blamed for the combustion. This view, however, does not express the whole truth. Carbon combining with oxygen to produce carbonic acid evolves 7,900 units of heat (Andrews), this unit being the quantity of heat required to raise one kilogram of water 1° C. This amount is invariable.

Grass, when growing in the field, is covered with numberless microscopical organisms, whether vegetable or animal, matters not for our present purpose; it is sufficient to state that amongst their number are very many which, in the course of their growth, consume oxygen and give off carbonic acid in great quantity, and derive their nutriment from substances of vegetable origin. Such organisms as these are the active agents in every kind of decomposition by fermentation.

If hay were stacked immediately it was cut, it would, in a very short time, become mouldy; its organic structure would be broken up by the feeding upon it of the parasites which prey upon it, and its power of affording nutriment to cattle would entirely disappear. Experience, gained in the remotest ages, has taught the farmer that these detrimental effects can be entirely stopped by the process called "curing the hay," *i.e.*, by choosing hot weather in which to cut the grass, and then allowing it to remain exposed to the sun's rays until it has become thoroughly dry. Such hay not only keeps perfectly good, but does not take fire, however long it may be stacked.

What has the farmer done? He has by evaporation removed the water from the interior of the stalks and leaves, and has by so doing cut off from the germs of ferment the means of absorbing into their own organizations the sustenance which the grass would otherwise have afforded them. But he has done something more than this. He has, by exposing the grass to the high temperature of the summer sun, destroyed the life in a very large number of the germs themselves. Whilst the grass was living, they were preserved from the intensity of the heat, by reason of its absorption by the grass; but, so soon as the grass was cut, it lost its power of gathering up the heat, so that by far the greater part of the germs have lost all chance of doing further mischief.

FERMENTATION PRODUCES HEAT.

Hay, properly cured, is not much damaged, even if afterwards partially moistened while being stacked, nor is it liable to take fire. Suppose, however, that the hay, instead of being thoroughly dried, was stacked whilst still damp; or that, though dry it had not been exposed long enough to the sun's rays to kill the larger part of the microscopical germs, and subsequently was accidentally wetted. The germs would grow, would throw off millions of offshoots, would prey upon the grass, drink the water, and breathe the oxygen, which, however closely packed the hay may be, nevertheless penetrates to the innermost recesses of the stack. In doing all this, they would produce carbonic acid, and this fact alone is sufficient to prove that heat must be generated, since carbon and oxygen cannot be combined without giving forth heat, any more than carbonic acid can be broken up by the plant without absorption of heat.

The ferment germs also induce other dangers of the vegetable structure in which heat is evolved, but if their formation of carbonic acid stood by itself, it would be sufficient proof that they are heat producers.

Fermenting germs feed by choice on the juices of the plant; this peculiarity of their growth aids spontaneous combustion, inasmuch as it leaves a large part of the carbon in a fine state of division, and the better able to condense and combine with oxygen.

The center of a fermenting haystack, when on the point of combustion, is blackened as if charred, and a sudden influx of air is almost certain to cause it to blaze. This is well known by farmers, and if on testing a suspected stack (by thrusting into it an iron rod and withdrawing it) they find the middle dangerously hot, they admit air to cool it by degrees, and with much caution.

The heat produced by the germs has no means of escape; it therefore accumulates, and at last, as in the case of the oily waste, varnish, rags, etc., a temperature is reached at which the woody fiber and oxygen can combine directly, vivid ignition takes place, and conflagration of the whole stack ensues.

That this is the real course of events, and that water, without germs, is powerless to set hay, cotton, jute, and other woody fibers on fire, is indirectly proved by the mode of making a hot-bed practised by gardeners when manure is scarce. Having taking a quantity of hay sufficient for the required purpose, this is spread out in a thin layer, and, according to the weather, watered several times a day for several days, or perhaps a week. It is then raked together in

a heap, and left to ferment, and soon becomes hot enough to be used for the required purpose. Or a space of ground the size of the intended hot-bed is covered with a thin layer of hay, and watered; after a short time a second thin layer of hay is put on and watered, and so on until the hot-bed has the required depth; the frame is then put on, and in a short time a very high degree of heat is attained.

If water were the only thing required to set the fermentation at work, it would surely be sufficient to water the heap when thrown together, but this is found to be inadequate to cause the hay to become heated. Why? Because the hay, if properly cured, has had so many of the germs killed that enough do not remain to start and keep up an active fermentation. No doubt, in time, the whole mass would ferment, but it would not do so until fresh germs had been imported into the heap, or the few that remained had time to multiply. When the hay is spread out in a thin layer, a large number of germs settle upon it, and when afterwards heaped up, the greater part are carried to the middle of the heap, where the heat can be retained, instead of being for the most part on the outside, as they would be if the hay were piled up before it was watered. Since then the heat which fires a hay-stack is the result of oxidation produced by fermentation, and inasmuch as it has been abundantly proved by Pasteur and others, that fermentation is decomposition of organic structures brought about by the growth and multiplication of living organisms, whose seed is ever floating in the air, it necessarily follows that to these minute seeds the combustion is due. Thanks to the indefatigable exertion of our foremost scientific men, the world at large is at least beginning to appreciate the immense power of destruction possessed by these living creatures, some of whom, though so minute as to be invisible to the human eye when assisted by the most powerful microscope, can yet light up a beacon to alarm a whole county side; whilst others of their brethren can in a few weeks devastate a continent, killing more cattle and men than would fall in an extensive, prolonged, and bloody war.

SPONTANEOUS COMBUSTION OF COAL.

The most serious cases of spontaneous combustion are in ships carrying coal. These have of late been so numerous, and have so often occurred in despite of manifold precautions, that a royal commission was recently appointed to make inquiry into the causes of these terrible catastrophes, and to suggest remedies which it may be possible to adopt for preventing and guarding against them. Numerous Board of Trade inquiries had already been made into casualties caused by explosions or fires in coal-laden vessels, but without any improvement in the safety of shipment resulting therefrom, until, at length, the board declined to hold any more, for the reason that the findings of their courts (which invariably took the form of an exoneration of the ship's officers, and a recommendation in favor of better ventilation) appeared to be entirely disregarded, both by shipping and underwriting interests.

It was evident, from this state of things, that the coal shippers conceived that they knew more of the causes of these accidents than did the assessors of the Board of Trade. The Salvage Association thereupon urged that an inquiry should be held by a commission, consisting of men of high scientific attainments, and especially acquainted with the nature of coal in all its conditions, and of men practically acquainted with coal, both at the pit and in the ship's hold. They pointed out that the result might be to fix, with a certainty absolute or qualified, the causes of this dangerous combustion, thereby attaching to proper persons the responsibility for due precautions

The Commission sat, and has now issued its report, from which much valuable information as to the nature of these disasters can be obtained, and, to a certain extent, modes of preventing them, though this part of the subject still requires most serious consideration, since at present the carriage of coal for a long distance at sea must be regarded as hazardous, whatever precautions may be adopted.

At the commencement of the inquiry, they were struck by the circumstance that by far the greater part of the casualties happened on board ships which were on long voyages. In 1874, among 31,116 shipments, amounting to upwards of 13,000,000 tons of coal, the accidents were 70. But of these shipments, 26,000, amounting to over 10,000,000 tons, were to European ports. This left 60 casualties among only 4,485 shipments, amounting to 2,855,831 tons of coal, to Asia, Africa, and America.

Again, they were startled to find that the proportion of casualties traceable to spontaneous combustion increases, *pari passu*, with the tonnage of the cargoes. This becomes still more apparent when the European trade is deducted.

There were in 1874:

2,109 shipments with cargoes under 500 tons, in which 5 casualties occurred—or under ½ per cent.
1,501 shipments with cargoes between 500 tons and 1,000 tons, in which 17 casualties occurred, or over 1 per cent.
490 shipments with cargoes between 1,000 and 1,500 tons, in which 17 casualties occurred, or 3½ cent.
308 shipments with cargoes between 1,500 and 2,000 tons, in which 14 casualties occurred, or over 4½ per cent.
77 shipments with cargoes over 2,000 tons, in which 7 casualties occurred, or 9 per cent.

The casualties in vessels bound to San Francisco were the most remarkable. Deducting vessels under 500 tons (in which no case of spontaneous combustion were recorded) the returns show 9 casualties out of 54 shipments. These also increase in proportion to the tonnage of the cargoes, till we find that, out of 5 ships with cargoes of over 2,000 tons sent to San Francisco in 1872, 2 suffered.

Careful thought might have predicted results of this kind, from a consideration of the nature of the substance carried, the mode of carriage, and the place to which it was going.

So long ago as 1852, Graham pointed out that the tendency of coals to spontaneous ignition is increased by a moderate heat, and gave examples. For instance, in one case coal had taken fire by being heaped for a length of time against a heated wall, the temperature of which could be easily borne by the hand; in another, coals ignited spontaneously after remaining for a few days upon stone flags covering a flue, of which the temperature never rose beyond 150° Fahr. Coals thrown over a steam-pipe ignited, etc. At the Chartered Gas Works, coals piled against a brick wall two feet thick, of which the temperature did not exceed 120° to 140° Fahr., became ignited. Neither did it appear to matter whether the coal was Lancashire and sulphurous, or Wallsend and bituminous. If they were exposed to this very moderate heat for a short time they were sure to ignite.

Coals conveyed through the tropics are certainly put in this state of danger. When coal takes fire spontaneously, it is invariably in the center of the heap of small coal at the foot of a hatchway, or in the middle of the cargo, in this respect resembling the spontaneous combustion of hay-stacks, oily waste, etc., and from hence it may be inferred that the increments of heat which cumulate in vivid combustion are very small, since they require to be held prisoners by impassable barriers of non-conducting matter, or they would escape.

Coal in small quantity, and in a cool place, never ignites spontaneously, but it does not, therefore, follow that all the conditions leading up to spontaneous combustion are absent, but only that one of them, and that an all-important one, the means of accumulating of heat, is absent, since the barriers interposed to its escape are not sufficiently close-fitting.

The large ships to San Francisco had to encounter elevated temperature, and at the same time the coal was in great mass; they were, therefore, much more reliable to accident than those carrying smaller quantities, and for shorter distances.

It has already been pointed out that, whilst wood is living, moderate heat, so far from causing its destruction, promotes its growth; it is the heat which disappears, not the plant. When the wood has ceased to live, moderate heat dries up its juices, renders it brittle, and ultimately causes its complete disintegration and combustion of air is supplied, though the process is exceedingly slow. Some years ago, the sawdust packing round a steam pipe at the Queen's Printing-office, Shacklewell, was found to be charred. Wooden beams resting against hot plates which never reach the boiling point of water, are sometimes found to be charred, but oxygen being of necessity excluded by the position of the wood, combustion does not happen.

At the ordinary temperature of the air, oxygen has so little action upon wood that it is practically indestructible. In coal, however, the wood has undergone changes which render it far more readily affected by the oxygen of the air than it was heretofore, and it must be borne in mind that if once a combustion is sufficiently rapid to overcome the cooling effect or currents of air, it will proceed with increased vigor, and the ignited coal will burn, not only in the interior of the cargo or heap, but on its surface also. Knowing, then, that coal if kept in bulk at a temperature slightly raised above the common is sure to ignite, the question still remains,—How does it attain the degree of heat at which active combination can take place? And at what temperature do the combinations of the carbon and oxygen, the hydro-carbons and the oxygen, begin to take place? In other words, what is the temperature of the initial point of the combustion, and how is it reached? Many explanations have been given. The well-known fact that heaped-up iron pyrites in shale, when wetted, often causes the combustion of the pile, as in alum making, has been used as an argument against the shipment of "brassy" coal, *i.e.*, coal containing these pyrites. But, supposing this were so, and that the pyrites were disseminated through a part of the cargo in sufficient quantity to cause evolution of heat when wetted, this would account for but a small number of the cases of spontaneous combustion of coal, since by far the larger number happen with coal free from pyrites.

HOW CARBON SPONTANEOUSLY IGNITES.

Condensation of oxygen by carbon, which was referred to at the outset of this paper, is a far more likely mode of attaining the initial temperature. This is pointed out by Professor Abel and Professor Percy in the appendix to the report of the Royal Commission. As already stated, carbon, in a finely-divided state, has the power of condensing oxygen within its pores; now, to condense a gas, force is consumed, and heat is produced. In the fire-syringe a piece of tinder is set on fire by the heat evolved by the condensation of the air. When charcoal condenses oxygen, heat is liberated, and if the charcoal is freshly burned, the rapidity of the action will produce such an amount of heat as to cause the chemical combination of the oxygen and carbon, when, of course, combustion takes place with evolution of light and heat. The initial temperature of the action is here due to the sudden squeezing together of the gaseous molecules, for if the air be admitted to the freshly-burned charcoal by slow degrees, no combustion takes place.

The Appendix suggests:—

"The tendency to oxidation which carbon and carbon compounds, existing in such a substance as charcoal, possess, is favored by the condensation of oxygen within its pores, whereby the very intimate contact between the carbon and oxygen particles is promoted. Hence the development of heat and the establishment of oxidation occur simultaneously, the latter is accelerated as heat accumulates, and chemical action is thus promoted, and may, in course of time, proceed so energetically that the carbon or carbo-hydrogen particles may be heated to igniting point.

"This explanation has a direct bearing upon a spontaneous ignition of coal. The more porous and readily oxidizable portions of coal, which are known to be more or less largely disseminated through seams from different localities, undergo oxidation by absorption of atmospheric oxygen, and by the exposure of large surfaces to its action, and the heat developed by that action, will accumulate, under favorable conditions, to such an extent as soon to hasten the oxidation and the consequent elevation of temperature, until some of the most finely divided and readily inflammable portions actually become ignited."

Water does not assist in the spontaneous combustion of coal, except where pyrites are concerned. There is much misunderstanding as to the part played by water in the changes leading to spontaneous combustion. The water itself is not decomposed, as some people have imagined. The heat evolved during the combustion of hydrogen and oxygen, during the combination to form water (the heat of the oxy-hydrogen blow-pipe) must be supplied before they can be again torn apart, so that, so far from water being a producer of heat, it is likely to be a consumer.

Moreover, experiment goes to prove that coal requires no initial temperature for its combustion, and that the supposition of condensation by porous coal, though it may take place, is unnecessary for its spontaneous combustion. The ties holding the constituents of coal together, which in the living plant were so strong that they defied the power of the sun to rend them asunder, have now become so weak that the oxygen of the air, even when no hotter than 55° Fahr. can seize upon and combine with at least some of the carbon, forming carbonic acid. Air blown through a tube filled with coarsely powdered coal, into baryta water, furnishes a considerable amount of barium carbonate in a very short time. Other circumstances may aid, but it is sufficient to prove the production of carbonic acid to make it certain that heat is set free, and if escape of the heat is barred, it must accumulate, till at length it reaches the point at which combustion becomes visible, and in too many cases uncontrollable.

As there is no amount of cold which may not be intensified by free radiation, so there is no limit to the heat which may be produced by concentration, or, in other words, by stoppage of all radiation except to one common point. Siemens' admirable regenerators act on the principle of continuous passage of heated gases through passages, where the gases are deprived of heat; when the heat-producers go forth to do their work, they are first made to pass through these heated passages. In addition to their own proper heat, they thus convey forward the stored-up heat, and the most intense heat yet met with for practical purposes is attained.

It is to be feared that, in ventilating the cargoes of coal-ships, the principle of Siemens' regenerator is infringed upon, to the great damage of the cargo. Air is forced through the coal, oxidation and heat follow throughout its course, the heat is absorbed by the coal, and the air, as it is continuously forced in, passes over surfaces which are becoming hotter and hotter, the air is itself heated, and the work of combustion, once begun, goes on more and more rapidly.

In view of these facts, there is small wonder that the uniform recommendation of the Board of Trade Assessors, "To ventilate the cargoes," should have met with cavalier treatment. The subject is, however, yet far from being fully understood. Evidence has been collected from most trustworthy sources, and a clear understanding obtained of the various conditions under which spontaneous combustion of coal takes place. What is now wanted is a thorough experimental investigation of the causes of the spon aneous combustion. The reasons already given are probably correct, but they are supported by the feeblest experimental support, and until this is strengthened, we can neither speak with the necessary boldness in reproving the actions which lead to the lamentable losses of good fuel, good ships, and, but too often, of good men; nor can we decide as to the proper means for preventing their occurrence.

INTERESTING EXPERIMENTS OF FARADAY.

In the course of the discussion which followed, Mr. Pearsall said he was inclined to think that one fertile source of mischief had been overlooked. He should like to raise the question whether coal and other hydro-carbons might not give off a hydro-carbon, as yet without a name, which was capable of spontaneously taking fire on contact with the air. Those who had experience in the distillation of oils, turpentines, and tars, were aware that there were many explosions and conflagrations when dealing with those substances, though it was not in the interest of the parties to magnify them, and they were generally kept quiet. He hoped, therefore, that this point would be further investigated. There was an experiment carried on for some days at the Royal Institution, where the temperature was regulated with boiling oil. It was under the direction of Mr. Faraday, and it was a question of the condensation of gases, and what would take place when substances were raised to a given temperature. He remembered very well assisting Mr. Faraday at the time, and late in the evening of about the third or fourth day the oil took fire. Preparations had been made to cover over the small vessel which was over the sand bath, which cut off the flame, but it again took fire, and then it was agreed to desist from the experiment, and Mr. Faraday took the small cauldron out into the yard, and after some minutes took the board off the top, but it again burst into flame, and this was repeated not three or four times, but fully twenty times, and he distinctly recollected Faraday calling his attention to the fact that it burst into flame when it was nearly cool. That was a case where oil had been heated repeatedly for several days, and apparently gave off some hydro-carbon, which was exceedingly inflammable. This point was of great importance, especially in considering the cases of those enormous warehouses where fire sometimes took place, as showing the difficulty of extinguishing them, because if they were aggregated together an enormous mass of sugar and other things at that temperature, and if, as these experiments seem to show, when you had a porous body and the air around it capable of absorbing the vapors so given off, and if some of these inflammable hydro-carbons were then introduced capable of bursting into flame, it would appear that there was no means of extinguishing it until the thing had burnt itself out.

Mr. Hatcher asked if Mr. Vincent could give any information whether the size of the coal had any influence on its liability to take fire; having stored large quantities of coal in the winter, his impression was that nut coal was more liable than any other; in fact, they almost always found it heat, and sometimes take fire.

Mr. Woodall asked if the presence of moisture in coal had no influence on the tendency to heating and ignition. His own experience with quantities of coal stored in close rooms, was that if stored when moist they were much more likely to ignite than if stored dry. Also, that if stored rough and coarse there was anything but the same disposition to ignite, as if very small. He had had the storing of some 10 or 20 thousand tons during the greater part of the year, and had never found any disposition to ignite either on the part of large or nut coal, but always with small coal. Mr. Vincent had pointed out some of the reasons why ignition took place, and having found out the causes, he hoped that some means could be suggested for avoiding the effect. In some ships, as well as in many stores, efforts were made to ventilate the coal, and he had known stores constructed specially with gratings for the purpose of bringing a current of air up along channels through the coals. In other cases, however, every possible attention was taken to exclude the air as thoroughly as possible, and, as far as his own experience went, the latter means had been most effectual.

Mr. Hughes said it was always a rule at Cardiff for the hatches to be kept open when a coal ship was in port, which would tend to show that the introduction of air, or allowing the confined gases to be given off, was considered beneficial.

Mr. Wills remarked that this question was one of grave importance. Combustion, of whatever kind, was a relative matter; it depended as much upon the supporter of combustion as upon the combustible itself, and it was necessary in any case, in order for combustion to take place, to have both a combustible and a supporter of combustion present. Beyond this first condition there was another equally necessary, namely, that the initial temperature at which the body took fire should be reached. That initial temperature must be reached either slowly or rapidly, and it follows as a necessary consequence that those bodies which had the lowest ignition points would be in this respect most dangerous. Spontaneous combustion is not a phenomenon which occurs without any previous warning, but it is simply the result of

accumulated heat, causing a combustible to unite with oxygen so actively as to produce ignition. This initial temperature of combustion was, in most cases, reached very gradually; but, in order that it should be reached at all, it was necessary that air, or oxygen, should penetrate into the mass of the material, and that this should not be able to travel through it at any great speed, but should remain for a definite time in contact with the combustible material, in order that the heat generated should not be carried away by radiation or conduction; because it was evident that, if the heat were carried away as rapidly as it was generated by the union of the oxygen with the combustible, it could not be raised to the initial temperature necessary for ignition because the heat would be decreasing rather than increasing. Mr. Vincent had stated that some people seemed to hold the view that, when coal was damp, it was necessary that the water should be decomposed in order for it to take fire; but that point did not arise at all. When bodies were moist, oxidization went on more rapidly, and therefore wet coal or other combustible material, such as hay, would unite with oxygen more rapidly than when dry. There were two ways in which evidently spontaneous combustion might be prevented; one was by totally excluding the supporter of combustion, i.e., air or oxygen, and the other was to so thoroughly ventilate the combustible material that all the heat produced should be carried away as rapidly as it was formed, and thus the initial temperature at which ignition took place could never be reached. These two methods were very carefully gone into by the Royal Commission, which he believed came to the conclusion that it was better to exclude the air altogether than to attempt to ventilate the combustible material, because you could not ventilate it uniformly; and even if you could, you were still liable to the chance that in some particular part heat was being generated, although the other portions might be cool. Spontaneous combustion in coal mines was a point of great importance, and Mr. Galloway, who had recently investigated this subject, was inclined to think that certain combustions took place on account of exceedingly fine coal-dust, which was found diffused throughout the atmosphere of the mine, and which acted like a combustible gas. The ignition point of this mixture of fine coal-dust and air was low, and under certain circumstances he thought that spontaneous combustion might occur, and undoubtedly it added very much to the force of an explosion when once set up, because it had been found in certain collieries that the explosion had been carried far outside the limits of the inflammable gas. The same thing had been observed in the case of flour mills, where the flour diffused through the air had been ignited at one point, and had travelled like a flash of flame from one portion of the building to the other.

The Chairman said that the paper which they had heard had not only been instructive, but also valuable, in eliciting a very interesting discussion, and some of the points which had been raised were so intimately connected with the subject, which he, as a member of the Royal Commission, had been investigating, that with Mr. Vincent's permission he would reply to them. In the first place, reference had been made to the state of division of the coal as influencing the tendency to spontaneous combustion, and after what they had learnt as to the effect of fineness of division of substances in promoting their union with oxygen, and the rapidity of that union, and the consequent heat evolved, there was no difficulty in conceiving that if coal were reduced to a comparative fine state, but in such a state that air could have access to a large surface, then you had the conditions favorable to ignition. If coal were very finely divided, indeed, it would pack so closely that air could have little chance of circulating, and the small quantity found in it would very soon have exhausted its action. Any attempt at ventilating coal of that description would have very little effect in promoting a further change, but if coal were reduced to a state not so fine, but still comparatively small, in which the form of the particles favored circulation of air, then if you promoted the continued action of air and the evolution of heat due to that action, you were in fact promoting the tendency to spontaneous ignition, so that there was a limit to the influence which the reduction of coal to a fine state of diffusion might have in promoting this effect. With regard to the action of the water, there were two distinct causes giving rise to the spontaneous ignition of coal. One was the oxidation of certain portions of coal, which consisted of carbon and hydrogen, and not readily acted upon by the atmospheric oxygen, besides which the coal contains, condensed within its pores, certain gases. Then you have the action of pyrites or sulphide of iron—a substance very prone to oxidation especially if in a comparatively moist condition. In the case of iron pyrites, the moisture acted as a carrier of oxygen to the sulphur and to the iron, and promoted the rapidity of oxidation when once it had been set up, so that where you had pyritic coal, full of "brasses," as it was termed, you had one, the tendency of which to spontaneous heating would be promoted by wetting. If, on the other hand, the tendency was due to the existence in the coal of certain carbon and hydrogen compounds, probably the wetting would have the opposite effect, because there the action was due to the tendency to absorb and condense oxygen, and if you filled the pores of the material with water they would be so far precluded from absorbing or condensing oxygen; and, therefore, that source of the accumulation of heat would be reduced. The action of water, therefore, might promote the generation of heat or not, according to circumstances. Indeed, a large proportion of the casualties which occurred in coal had been due to the action of pyrites, but there was also very many which could not be traced to that cause, or to its containing that particular kind of pyrites which was specially susceptible of rapid oxidation. Pyrites, although identical in chemical combination, would vary very considerably indeed with regard to its tendency to oxidation. Two samples possessing the same chemical composition, and differing only slightly in mechanical structure, behaved very differently indeed in this respect, so that you could not always assume that because coal was rich in pyrites it was necessarily prone to spontaneous combustion; still the fact remained that there was this tendency in pyritic coal. A curious point came out in the evidence before the Royal Commission, that since the Mines Regulation Act came into operation, which rendered the employment of boys comparatively difficult, coal had become more pyritic, and was shipped in a much dirtier condition with respect to this particular inpurity. Boys were largely employed to pick over the coal and pick out the brasses, and when the Act came into force this ceased to a great extent, and the examination of the coal became comparatively imperfect. With regard to ventilation, Mr. Wills had given the true explanation of its useful and mischievous effects. If you so ventilated a cargo as to continually sweep air through it at all points so rapidly as to carry away the heat as fast as it was generated, you would undoubtedly put a stop to the chance of spontaneous ignition, for this so-called spontaneous ignition was due to the gradual heating up of the material until the point was reached when chemical action was set up very rapidly, and to an extent sufficient to raise the substance to a red heat. But in the case of coal cargoes, it was absolutely impossible so to arrange a ship that air could be uniformly and with certainty drawn through every portion of the cargo. The mere fact of its being more or less broken in different parts would point how difficult it must be, but even supposing it entirely consisted of a uniform mass it would be very difficult to draw air through it so as to keep it completely cool. If, however, this could not be done, no doubt ventilation became mischievous, because then it only supplied additional oxygen instead of allowing that existing in the mass of the coal to become exhausted in its action. Many remarkable instances were produced, with regard to this point, before the Commission. It was at first believed that ventilation was the thing to be aimed at in coal ships, but it soon came out that the majority of casualties arose in ships where attempts had been made to ventilate, and one very remarkable instance was mentioned. Four large ships were laden with coal at Newcastle, all the ships receiving the same kind of coal and at the same time, so that there were the same conditions as to weather, &c., and the ships were exactly of the same burden, from 1,500 to 2,000 tons each. Three of them, which were bound for Aden, were notably lost from spontaneous ignition, whilst the fourth arrived at Bombay and discharged her cargo safely. The only difference was that the three of them were ventilated, whilst the fourth was not ventilated at all. There was one other point, however, with regard to ventilation, which had not been noticed. Mr. Vincent had dealt only with the one subject of spontaneous ignition; but there was another source of accident, namely, that due to the ignition of explosive mixtures of air with the gases which gradually escape from coal, especially if placed on board ship soon after it was brought from the pit. Masses of coal, especially from certain seams, contained within its pores a considerable quantity of inflammable gas—the same mixture, in fact, which constituted the fire damp of coal mines. This gradually escaped—sometimes only to a trifling extent, at other times to a considerable extent—and would gradually diffuse itself through the air in the vicinity of coal cargoes, and thus form an explosive gas mixture which might eventually reach some source of light and become ignited and produce an explosion. Many of the casualtics to coal vessels were due to this cause, and ventilation of a particular kind was very valuable in guarding against accidents of this description. If you could keep up a consiant current of air over the top of the coal cargo, these explosive gases would be drawn off and carried out of the ship; so that surface ventilation was extremely important in connection with coal cargoes, and should be insisted upon; whereas ventilation through the cargo should not be attempted. In conclusion, he proposed a vote of thanks to Mr. Vincent for his interesting paper.

The resolution was carried unanimously, and the proceedings terminated.

FLASH-SIGNALS.

By D. BRUCE PEEBLES.

THE apparatus consists of an ordinary gas-governor (1)—the one we have here is a dry governor, but it may be either of the wet or dry kind; it is entirely inclosed—and a small controlling governor (2) arranged to throw the pressure of the inlet gas upon the bell or diaphragm of the larger or supply governor, thus opening the valve. A small stream of the inlet gas flows into and out of the diaphragm, or bell chamber, and may be let away through an orifice, either into the main outlet or by a separate outlet-pipe, thus allowing the governor to be easily controlled, and weights being put on or taken off, the small governor opens or closes the valve of the large one.

The small governor (2) is loaded to give a supply of gas just sufficient to keep the burners lighted, or this may be done by means of a by-pass, with regulating stopcock; and a separate weight, sufficient to give a maximum supply of gas, is connected to one end of a lever (3), the other end of which is fitted with an armature (4) in a position to be acted on by a small electro-magnet (5). When the electric circuit is closed, the magnet causes the lever to lower the weight on to the small governor diaphragm and open the valve; but the weight is suspended from the lever by a loose link (6), so that only the pressure of the weight acts upon the governor. When the electric circuit is broken, the lever, having its armature end sufficiently heavy, lifts up the weight from the governor, and closes the valve. We see, therefore, that the small governor acts on the large one, by loading or unloading the bell or diaphragm with pressure instead of weights; and this principle may be modified and carried out in several ways. The electro-magnetic action is got from a small bichromate battery (7), and the small timepiece (8), which makes and breaks contact, is arranged to give six flashes each minute—but any other reasonable number of flashes can be given, if required—while 1,000 lights can be as easily acted on as the seven we have here. For lighthouse purposes, or wherever a timepiece is employed to work the apparatus, it may be considered preferable to dispense with electricity, and place the lever (3) in a position, so that it may be acted on directly by the clock, and this can readily be done by a simple mechanical arrangement, as a very small amount of power is required to lift the lever and lower the weight on to the small governor. We now put the apparatus in action, and it will be observed that the flashes are given with a precision that leaves nothing to be desired. It will be readily understood that, while the rapidity of the flashes can be greatly increased, the duration of the flash can be prolonged, if necessary. The small current of controlling gas may either flow into the main outlet-pipe, or into a separate pipe, as before stated; but it is advantageous in this case to make the outflow pass through the small orifice by a separate pipe (9), as by increasing or diminishing the size of the orifice the flash may be made sharp or sluggish, as wished, without in any way altering the pressure of the gas supplying the signal-lights.

This method of flash-signals may also be applied to railways, and a train may be made to give a visible signal of its approach at any distance from the station. A powerful gas-light might be placed at any central point which could easily be seen from any part of the station where the train is expected, and it would only be necessary to get the wheels of the engine or carriages at a mile or two miles distant, as the case might be, to touch a spring, make contact, and close the circuit, when the light would at once flash forth at full power, warning those at the station that the train was approaching.

The light could either be allowed to go down after the train had passed the contact spring, or remain as a signal until some of the officials at the station released the catch-pin, thus letting the gas down again to a minimum.

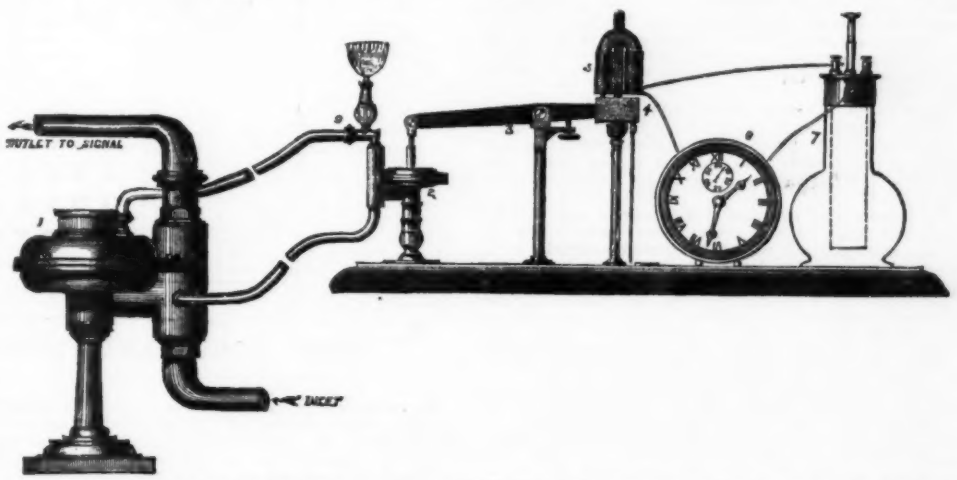
The system might also be used for giving a visible time-signal all over a city, say, at nine o'clock every night, so that in every house in which gas is used, the time could be obtained by noticing the gas-flame, which would be lowered for a second or two at the particular hour agreed upon. This could easily be done by acting on the station-governor at the gas works, and correct time would be insured by using one of Mr. Frederic Ritchie's regulated clocks, a number of which are now in use in Edinburgh and other places.

It seems well adapted also for Professor Jenkins and Sir Wm. Thomson's system of eclipse signalling by the Morse alphabet, the dot and dash being represented by long and short period of darkness.

A method of balloon signalling might also be established wherever a supply of gas could be obtained. The balloon would carry up flexible gas-tubes, and the flame would be protected by a lantern and wind-guard. In such a case, if used for war purposes, a cypher would be fixed on for giving the messages, and the gas might be compressed and transported to any suitable place for giving the signals.

There is yet another purpose it might be applied to. A small apparatus of this sort might be attached to the gas-pipe of any licensed houses whose landlords were suspected of setting Forbes Mackenzie at defiance. It would, in such a case, be set to turn off the gas at eleven o'clock P.M., and put it on on again, say at six A.M. The authorities would only have to see that the clock and battery were attended to once a week, and might then rest assured that, so far as gas was concerned, no supply would be had after the legal hour of closing.

Lastly, it could be attached to the station-governor of any gas-works, and adjusted so as to give the day and night pressure at any hours the manager wished, so that, if all of us here who have station-governors had also a controlling apparatus such as this, we might have set it before leaving home to-day, with a certainty that the night pressure would be put on in our absence at the exact hour we arranged the timepiece to make contact.—*Journal of Gas Lighting.*



PEEBLES' ELECTRIC FLASH-SIGNALLING APPARATUS FOR LIGHTHOUSES, RAILWAYS, ETC.

AERIAL TELEGRAPHY.

AERIAL telegraphy without wires or poles is spoken of as among the possibilities of the future. Professor Loomis claims to have communicated with an assistant twelve miles away by means of an aerial current. The current was reached by flying kites a certain height at each point, the string used being a copper wire. When both kites had attained the same altitudes, in the same current, messages were sent and received at the distance mentioned by an instrument at the ground end of the wire, the only connection being the atmospheric current between the kites.

EVEN in the best qualities of glass, the long continued action of sunlight produces irisation. When the glass is examined at right angles to the surface, nothing appears to impair the purity of its transparency; but when it is looked at obliquely, minute and regular strie are easily discovered.

PROF. KOHLRAUSCH has tested the conductivity of alcohol, and he finds that it, in several instances, conducted better than pure water. This is contrary to the general belief that water conducts much better than alcohol. In the books both alcohol and ether have been set down as non-conductors, or as semi-conductors.

[TRANSACTIONS OF THE ROYAL MICROSCOPICAL SOCIETY.]

NEW THEORY OF MICROSCOPIC VISION.*

Observations on Professor Abbe's Experiments illustrating his Theory of Microscopic Vision.

By J. W. STEPHENSON, F.R.A.S.

IN my opinion, the very important theory of microscopic vision which has been enunciated by Professor Abbe has not received in this country the attention it pre-eminently deserves. The theory to which I refer is, that the microscopic images produced by certain objects of minute detail, such as diatoms, scales of insects, and other things, are not simply direct dioptrical images, such as the mere outline of an object, but are the result, in most cases, of the combination, or fusion together, of the central pencil with certain secondary images, produced by the *interference* of those pencils of light, into which, by diffraction, the incident beam of light is, in passing through the object itself, resolved; in other words, that the principal or central beam of light *alone* is not sufficient truly to depict fine lines, small apertures, or other minute structural details, but that, as far as resolution is concerned, two or more pencils are always necessary to produce the desired effect. These pencils may, or may not, include the principal or dioptric beam, but where the latter is excluded the image necessarily appears on a dark field.

Further, his contention is, that when from any cause whatever, whether from the angles formed by the intersection of lines or the closeness of the lines themselves, whether from the aperture of the object-glass, or when, by artificial means, the diffraction images, as seen within the body of the microscope, are made similar, the microscopic images themselves will be identical.

The diffraction images of a lined object, in focus on the stage of the miscroscope, may readily be seen by removing the eye-piece and looking down the tube of the instrument. Here, with the light central, and the lines on the object parallel, the colored spectra are distinctly visible, going off on either side at right angles to the direction of the striæ, the most refrangible rays next to the central beam of light. The latter fact is particularly mentioned, as it has an important bearing on the limits of visibility and on the photographic reproduction of microscopic objects.

Professor Abbe has supported his views by some very striking experiments, which appear to me to be a complete practical demonstration of the truth of his mathematical deductions; and by his permission, I propose to exhibit under the miscroscope this evening four or five of those which impress me as being the most important, and therefore the most interesting.

1*st Experiment.*—The purport of the first experiment is to illustrate the production of *identical* microscopic images by *different* structures, when, by artificial means, the diffraction pencils arising therefrom are made similar in number and position, within the tube of the instrument, as previously mentioned.

This experiment is made on a grating formed of alternately long and short parallel lines (Fig. 1), ruled with a diamond through a film of silver, of extreme tenuity, deposited on the under side of a thin glass cover, and subsequently cemented with balsam to an ordinary glass slip, the coarser lines being about 1,790 to the inch, and the finer about 3,580.

This grating gives rise to two sets of diffraction spectra, when placed beneath the objective, in the middle of the field, the set arising from the wider portion, being *exactly* half the distance apart of that arising from the narrower, such distances between the spectra, being inversely proportional to the distances between the lines themselves.

On removal of the eye-piece these two rows of spectra (Fig. 2) are visible, one above the other, as the eye is brought to see successively the air images at the upper end of the tube

It is obvious, from the figure, that as the wider grating gives spectra *exactly* half the distance apart, and therefore twice as numerous as those arising from the narrower, that the latter may be made to coincide with the former, in number and position (as required), by stopping out every alternate ray from the wider grating, beginning with the first.

This is readily accomplished by placing a stop close to the back combination of the objective, so constructed that a central slit will admit the central ray only, whilst another slit on each side will admit only the second spectrum of the wider and the first spectrum of the narrower grating (Fig. 3).

On replacing the eye-piece it will now be seen that the microscopic image of the narrower lines remains unaltered, but that the wider lines have doubled in number (Fig. 4), by an apparent prolongation of the shorter lines between them, making the two images identical, the upper part being distinguishable only from the lower by somewhat less brightness, which simply arises from the smaller number of real lines through which the line can pass.

Again, by stopping out all the spectra, except the fourth of the wider, and the second of the narrower (Fig. 9), the spectral aspect is again rendered similar in the two cases, and the microscopic images, though changed, will be still found to be identical, by the doubling of the narrower and quadrupling of the coarser lines (Fig. 10); but to see this distinctly, with so low a power as Zeiss' *a*, *a*, the fifth, or E, eye-piece is required.

I should state that, although in this experiment a Zeiss *a*, *a*, with a third eye-piece, has been used, any other object-glass of about 1 or 2 inch focus would do as well with a suitable stop; the stop used with the objective mentioned in this experiment has three slits, each $\frac{1}{40}$ of an inch wide, with the same distance between them.

2*d Experiment.*—In this experiment the same grating is used as before, with a diaphragm having a single central slit, so adjusted (parallel to the lines of the object) that one spectrum only will be admitted on each side, from the coarser grating, and none whatever from the finer (Fig. 5); the object of the experiment being to show that unless one spectrum at least is admitted there is no power to resolve the lines.

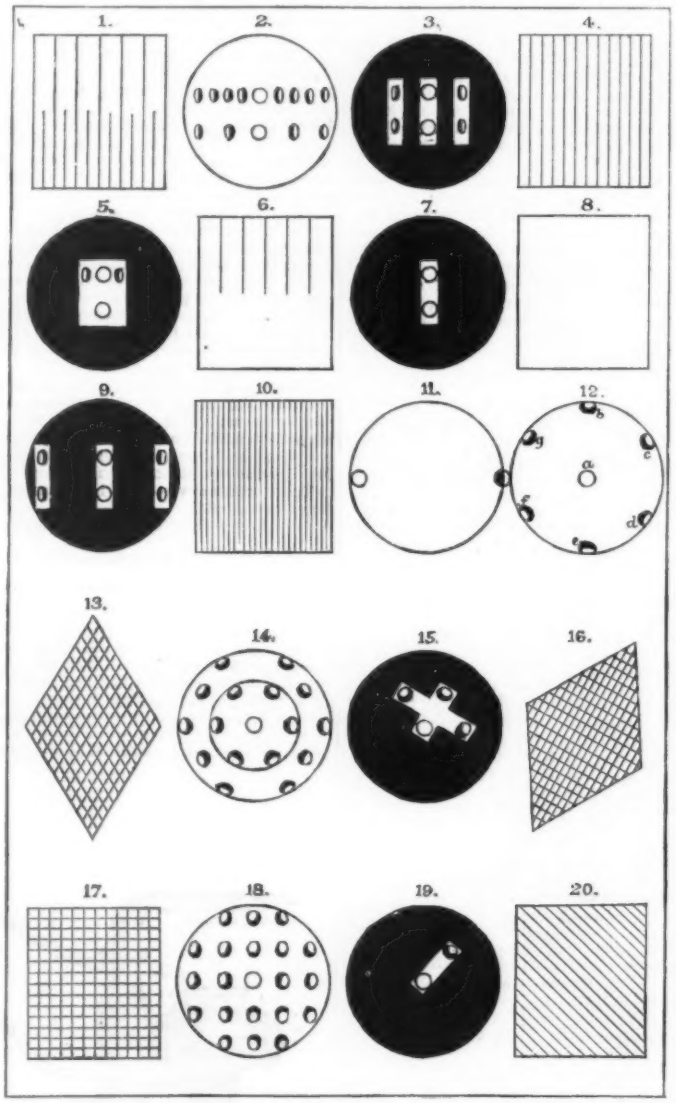
An examination of the eye-piece shows that this is so; by the reduction of the aperture the finer lines (the spectra of which are excluded) have disappeared and been replaced by a plain silver band, the coarser lines appearing in their normal condition, as anticipated by theory (Fig. 6).

3*d Exper ment.*—This experiment, like the former, illustrates the necessity of an amount of angular aperture sufficient to admit some spectral rays; in it the central slit is simply reduced to $\frac{1}{80}$ of an inch, which is sufficient to exclude the spectra of the coarser as well as the finer lines (Fig. 7). The examination shows that, even as far as lines 1780 to the inch go, all resolving power has departed, the two gratings being replaced by a plain silver band without any trace of lines.

In all these experiments in which a slit has been employed, it will have been observed that the sides of the slit are parallel to the direction of the lines; but it will be found that if the diaphragm is turned so that the slit is at right angles to the lines, all the spectra will be re-admitted and perfect definition result, proving that it is the position of the stops relatively to the striæ, and not their form alone, which produces the phenomena.

The ordinary adapter used for rotating the analyzing prism of a binocular microscope is a convenient instrument for adjusting the stops, which may be placed at the end of a small tube of a size suitable for entering the objective when necessary. The same effects of duplication or obliteration of lines may be produced on such an object as *Lepisma saccharina* by using higher powers with suitable diaphragms.

The limit of visibility is a direct consequence of the demonstration that no resolution can be effected unless at least two pencils are admitted; and as the admission of a secondary or spectral image is absolutely dependent on the aperture of the objective, it follows that the resolving power is a function of such aperture, of which we know the superior limit to be 180°; when the limit of resolving power with oblique light has been reached, the illuminating ray will be seen at the extreme edge of the back lens with the spectral image on the opposite margin, as in Fig. 11.



PROF. ABBE'S NEW THEORY OF MICROSCOPIC VISION.

The rule given by Professor Abbe for determining the greatest number of lines per inch which can be resolved by oblique light will be found (taking any given color as a basis) to be equal to *twice the number of undulations in an inch multiplied by the sine of half the angle of aperture.*

As the sine of an angle can never exceed unity, the maximum will be equal to twice the number of undulations in an inch in that ray of the greatest refrangibility which will afford sufficient light for the purpose. With *central* light, the maximum for any assigned color will be equal to the number of undulations in an inch. What that color should be is incapable of determination generally, as the capacity for appreciating light varies with different individuals.

If, for instance, we take 43*µ* in the spectrum as being sufficiently luminous for vision, we find the maximum, as far as *seeing* is concerned, to be 118,000 to the inch; but as the non-luminous chemical rays remain in the field after the departure of the visible spectrum, a photographic image of lines much closer together than those named might be produced.

How little is gained in "resolving" power by such an excessive aperture is at once seen when it is considered how slowly the sines of the larger angles increase, a reduction of the angle from 180° to 128½° causing a reduction of 10 per cent. only in the resolving power, with an immense increase in the general utility of the glass; or, if reduced to 106½°, we still have a resolving power equal, on the same hypothesis, to 94,400 lines to the inch.

The next experiments are made with crossed gratings, and give equally important results.

These gratings are prepared by ruling two sets of lines through silver films as before, one set being ruled on the under side of a thin glass cover and the other on the slide; the two pieces of glass with the lines in contact at an angle of 60° are cemented together with Canada balsam, and of course give rhomboid markings over the entire structure (Fig. 13).

4*th Experiment.*—The object of the first experiment with crossed gratings is to show that with a certain arrangement of the incident light both sets of real lines disappear, and are replaced by one set of perfectly distinct spurious lines parallel to a diagonal of the rhombic figure (Fig. 14). This is effected by using a single slit stop, with the slit in the direction of one of the diagonals, when the spurious lines will appear parallel to the other diagonal, and therefore at right angles to the slit.

If a crossed slit, as in Fig. 15, is used, two sets of spurious lines will appear at right angles to each other (Fig. 16), although the real lines, from which they originate, are at an angle of 60°. The reason of this will be at once understood, from the previous experiments, to arise from the admission of two sets of spectra, the directions of which are parallel to the diagonals.

An experiment identical in principle is shown on a rectangular grating, Fig. 17, in which with a slit admitting one spectrum, such as is seen in Fig. 19, both sets of lines (vertical and horizontal) disappear, and are replaced by one set (Fig. 20) intersecting the squares formed by the real lines, and therefore closer in the proportion 1 : $\sqrt{2}$.

5*th Experiment.*—The object of this experiment, which is perhaps the most important of all, is to show that, with only one row of spectra, the structure of such an object as that under consideration is absolutely indeterminate.

In this experiment the slit diaphragms are entirely discarded, and the crossed grating is examined with a simple circular stop, which is used merely for the purpose of so reducing the angle of aperture that the first row of spectra only shall be admitted.

The illumination is central, and an examination of the interior of the tube shows seven pencils of light, the bright dioptric beam being in the center of the field, with six equidistant spectral rays around the margin.

Let it now be clearly borne in mind that we are about to examine a structure which we *know to be entirely composed of distinct rhombic markings.*

On replacing the eye-piece for this purpose, we see *hexagonal* markings over the entire field, as in *Pleurosigma angulatum*, and this effect has been produced by simply so reducing the aperture relatively to the fineness of the object that the first spectra only are admitted.

From this microscopic image we can infer nothing as to the real structure of the object under examination; we know it to be rhombic, but it appears to be hexagonal.

But the bright central beam and six-colored spectra which have produced this result are identical in aspect with that presented by a single valve of *P. angulatum* with central light. Compare Fig. 12 and the inner ring of Fig. 14.

This diatom with central light, under the highest powers and with the largest apertures, necessarily presents the same spectral appearance, in consequence of the fineness of the striæ, or holes (whichever they may be), the dispersion being too great to admit the second row of spectra.

It has now been proved that, with the means employed,

* Read before the Royal Microscopical Society, 1877.

no definite inference could be drawn of the real structure of the artificial object, and it is equally certain that this demonstration will apply with equal force to the valve of *P. angulatum*, the hexagonal markings of which may, to use the words of Professor Abbe, arise from "two sets of lines, or three sets of lines or isolated apertures of *any* shape in the object itself."

If it were possible to admit the second row of spectra, a nearer approach to a knowledge of the true structure would be obtained, as the larger the number of diffracted rays admitted, the greater the similarity between the image and the object, the keystone of the theory being that "*the interference of* ALL *the diffracted pencils, which come from the object, produces a copy of the real structure,*" as in a dioptrical image; but this, as has been abundantly shown, is rendered impossible by the great dispersive power of many fine structures

Further illustrations of the formation of hexagonal markings may be found on the same diatom.

On bringing into focus a good specimen of *P. angulatum*, flat and with distinct-looking lines, using a broad beam of central light, the six diffraction spectra before alluded to may be distinctly seen within the margin of the back lens of the objective (Fig. 12). Any two adjacent spectra combined with the central cone of light will form an equilateral triangle, and produce the well-known hexagonal markings; but as any other pencils forming an equilateral triangle will also produce hexagonal markings, a *new set* on a dark field may be formed by excluding the central and each alternate diffraction ray; the sides of this triangle being longer than in the common figure, in the proportion of $\sqrt{3} : 1$, the new hexagons will be *three times* as numerous as those usually seen, and with their sides at a different angle to the median line. The three pencils producing the interference in this case are *g, e, c*, or *b, d, f*, and the hexagons will have their sides normal to the axis of the scale, not parallel as in the common image. Not only is this so, but it follows from the theory that there must be visible three other sets of lines, bisecting the angles between the common lines, and corresponding to the combinations of the spectra, *g, e*, or *f, d—b, f*, or *c, e—b, d*, or *g, e*. All these phenomena may be observed by stopping off the pencils which are to be excluded. It is easy to get the lines bisecting the angles of the common rows, one after the other, and of these one set parallel to the axis of the scale. For that purpose oblique light must be used, and the central beam and one of the peripheral rays must be stopped out, leaving for instance *b* and *f*, or *c* and *e* (*i.e.*, two spectra parallel to the median line).

EXPLANATION OF PLATE.

Fig. 1.—Fine grating used as the object on the stage of the microscope.
Fig. 2.—Appearance presented on removing eye-piece and looking down tube, showing central and spectral images.
Fig. 3.—Diaphragm with three slits in position, shutting out certain spectral images, and making those produced by coarse and fine lines identical.
Fig. 4.—Appearance presented on examination of object (Fig. 1) when examined under the latter condition; fine lines in normal condition, coarser doubled in number.
Fig. 5.—Diaphragm excluding *all* the spectral rays from finer lines, and all except the two adjacent to central beam from the coarser lines.
Fig. 6.—Shows the coarse strie alone; the finer invisible in consequence of all their spectra being excluded.
Fig. 7.—Diaphragm excluding *all* spectral rays.
Fig. 8.—No lines visible in consequence.
Fig. 9.—Diaphragm excluding all the spectra of Fig. 2, except the fourth of the coarse and second of fine grating.
Fig. 10.—Appearance presented; coarse lines quadrupled and fine lines doubled in number.
Fig. 11.—Effect produced by light of extreme obliquity on parallel lines of such fineness as to have nearly reached the limit of resolvability; the illuminating pencil at the edge of field, and only the more refrangible rays of spectral image remaining in the field at the opposite side.
Fig. 12.—Appearance presented in tube by single valve of *P. angulatum*; light central.
Fig. 13.—Fine crossed grating (60°) used as object on stage of microscope.
Fig. 14.—Spectral aspect produced by crossed grating; the spectra within smaller circle identical in form with *P. angulatum*, Fig. 12.
Fig. 15.—Diaphragm in position admitting central beam and three spectral rays; the imaginary lines joining them, crossing each other at right angles.
Fig. 16.—Appearance of Fig. 13 under these conditions; the lines crossing each other at right angles at distances inversely to those of the spectra ($\sqrt{3} : 1$).
Fig. 17.—Square grating.
Fig. 18.—Appearance presented in tube.
Fig. 19.—Diaphragm admitting central and spectral image.
Fig. 20.—Consequent disappearance of all real lines, and substitution of diagonal lines at right angles to admitted rays.

[NATURE.]

THE EFFECT OF INAUDIBLE VIBRATIONS UPON SENSITIVE FLAMES.

DURING a recent visit to Birmingham my friend and host, Mr. Lawson Tait, showed me some interesting experiments with one of Mr. Galton's whistles, capable of yielding vibrations beyond the limit of hearing. This led to the suggestion of trying a sensitive flame with these whistles, and in fulfillment of my promise to select and send to Mr. Tait a burner sensitive to very high notes, I was yesterday led to make the following experiment, the result of which is, I believe, new, and I think sufficiently interesting to put on record. A sensitive flame was obtained just two feet high when undisturbed, but shrinking down to seven inches under the influence of the feeblest hiss or the clink of two coins. Adjusting the Galton whistle, which Mr. Tait lent me, so as to yield its lowest note, little effect was produced on the flame; a shrill dog-whistle produced a slight forking of the flame, but that was all. Raising the pitch of the Galton whistle, the flame became more and more agitated, until, when I had nearly reached the upper limit of audibility of my left ear, and had gone quite beyond the limit of my right ear, the flame was still more violently affected. Raising the pitch still higher, until I quite ceased to hear any sound, and until several friends could likewise detect no sound, even when close to the whistle, I was astonished to observe the profound effect produced upon the flame. At every inaudible puff of the whistle the flame fell fully sixteen inches, and burst forth into its characteristic roar, at the same time losing its luminosity, and when viewed in a moving mirror, presenting a multitude of ragged images, with torn sides and flickering tongues—indicating a state of rapid, complex, and vigorous vibration.

Nor was this effect sensibly diminished by a distance of some twenty feet from the flame. Placing the flame at one end of the large lecture theatre of this college, and blowing the whistle at the furthest point away, a distance at least of fifty feet and more than thirty feet above the flame, still the effect produced was very pronounced. There can hardly be a more striking experiment. A single silent and gentle puff of air sent from the lips through the whistle, nothing whatever to be heard, and yet fifty feet away an effect produced that might readily be seen by thousands of people.

The extreme smallness of the amount of motion actually concerned in producing this great change in the aspect of the flame is evident. For the inaudible vibrations, having at their origin but a small amplitude, gave rise to a spherical air-wave,* which at a radius of fifty feet—and with the vast enfeeblement due to this distance—knocked down a two-foot flame, though the surface acted upon had an area of less than a square inch—for it is only the root of the flame that picks up the wave motion. Of course everything depends upon the delicately poised state into which the flame has previously to be brought. It then, like a resonant jar, enters into a state of vibration which appears to be synchronous with the note producing the effect. By this means it may be possible, with the aid of a mirror moving at a known speed, to determine the vibration number of these high notes, and thus with greater exactitude fix the upper limit of hearing.

The flame giving the effect here described was produced by coal gas contained in a holder under a pressure of ten inches of water, and issuing from a steatite jet having a circular orifice 0·04 inch in diameter.†

W. F. BARRETT.

THE MICROSCOPIC ANATOMY OF VACCINATION.

MESSRS. BRAIDWOOD & VACHER have published a very lengthy report on this subject in the *British Medical Journal*. In this they state the following conclusions: *a*. The principal local changes excited by the vaccine contagium affect the rete mucosum, and consequently the hair follicles. *b*. They consist in corpuscular infiltration of this tissue. *c*. The corpuscles to be most distinctly seen during the earlier days after inoculation, infiltrating this tissue, are oval or round nucleated cells, deeply tinged by carmine. *d*. On successive days, these corpuscles are to be seen in the crypts or hair follicles budding or throwing off minute, round, highly refractive bodies. *e*. During the later stages when the pock has nearly matured, these corpuscles elongate into fibers, or shrink up. *f*. In becoming fibers, they encroach on the hair shafts and hair follicles. In none of the preparations examined by us have we observed any bacteria, fungoid forms, or allied organisms.

A NEW THEORY OF THE ORIGIN OF TYPHOID FEVER.

THREE years ago, Dr. Stewart, of Barnsley, attended seven or eight cases of this disease in a row of cottages situated on a hill. He traced the outbreak to the decomposition of the blood from a slaughter-house in the row; the blood was allowed to flow into the common sewer, where it remained and putrefied. The waste-pipes from the sinks in the cottages were directly connected with this drain, without the intervention of any kind of trap, and the smell therefrom was often horrible. M. V. Feltz has found by experiments that putrid blood, when dried, mixed with distilled water, and injected into the veins of dogs, causes symptoms very analogous to those of typhoid fever. These symptoms were produced even when all trace of bacterial life had disappeared from the blood injected. While pondering over the above cases, Dr. Stewart's thoughts were directed to the analogies which exist between the symptoms of typhoid fever and those of certain cases of puerperal fever, which appear to arise from the introduction of the products of decomposing blood into the system through the lymphatics or veins of the uterus. Some of these cases have resembled ordinary typhoid fever of a severe type so closely that, if it were possible to have overlooked the puerperal condition, they might have been set down as cases of that fever. The local affections of the genital organs in puerperal fever seem to have obscured the true nature of these cases, by diverting attention from the ultimate general effects upon the system, and concentrating it too exclusively on the local expression of the infection. He thinks that the different channels by which the poison is admitted to the blood—in the puerperal case, by the lymphatics or veins of the uterus, in the typhoid case, by the stomach or lungs—would go far to account for any apparent variations in the symptoms. The poison, too, in the former case, is introduced in a recent and active form; in the latter, usually only after it has lain for a considerable time in the ground, and been washed or percolated into the wells.

A vast number of typhoid fever cases, however, appear to arise from the pollution of drinking water by the excrement of human beings. Now, Dr. Stewart thinks that if we settle upon the serum of the blood as the essential factor of the poison, it will be at once evident how any severe case of diarrhœa would be sufficient to produce the disease, because the liquid evacuations of severe diarrhœa are principally composed of serum of the blood, which is then placed under conditions highly favorable to the development of the putrefactive process. If both decomposing blood and the decomposing liquid evacuations of diarrhœa be capable of causing typhoid fever, then serum of the blood, which is the only component common to both, must be the poison factor. Dr. Low recently published several cases, which prove that the disease may arise from the inhalation of the emanations from fetid stools and privies. This theory of typhoid fever arising from the decomposition of the serous evacuations of severe diarrhœa accounts for the extraordinary prevalence of the fever, in the months of October, November, and December, in a more satisfactory manner than any other theory. In consequence of the great prevalence of summer cholera in July and August, abundant material is furnished for the elaboration of the poison, which afterwards percolates into the wells, or is washed by the autumnal rains into the sources of the water supply. Two or three months are probably necessary for this preparation.

Dr. Stewart does not enter into a discussion as to whether the disease can have an abiogenetic origin, though the facts on which his theory is founded seem to favor that doctrine. The questions whether the fever can only arise from specific typhoid germs, which are nearly omnipresent, and may remain dormant for years only to spring into active life when introduced into a proper nidus for their development; or whether the poison may be developed from the ordinary germs existing in all decomposing animal fluids, or is elaborated by some chemical change in the properties of the fluid itself, are, in his opinion, of little practical importance. —*British Medical Journal.*

SICK-HEADACHE.—Dr. H. W. Hendrick, of Hyde Park, Vt., has had excellent success in the treatment of sick-headache, by guarana in powders, grains five to fifteen for a dose—a dose—*Medical Record.*

* I have no doubt a similar result would attend an experiment made in the open air, if the air were still enough to allow it to be made.

† The conditions necessary for obtaining the utmost sensitiveness of the flame are described in an article I published on the subject in the *Popular Science Review* for April, 1867.

CURE FOR PRICKLY HEAT.

A NAVAL surgeon writes to the *Lancet:*

"I should like to bring before the section of the profession practising in tropical climates the following powder as a cure for that troublesome skin disease, "prickly heat." I used to suffer myself dreadfully, and tried all the supposed remedies without deriving any apparent good. Some, as carbolic acid, appeared to produce intolerable itching at night. Lately I have seen the local application of sulphate of copper recommended. The powder has the following percentage composition: sulphur sub., 80; magnesia oxidi, 15; zinci oxidi, 5. To be used morning and evening in the following way: The dry powder being on a plate, a wet sponge is pressed down on it, and a certain quantity will adhere; this is firmly rubbed on the parts affected, fresh moisture and powder being from time to time supplied, the application being continued ten to fifteen minutes each sitting. The parts are then washed clean of the adhering particles. I have never seen the worst cases last beyond four or five days. So complete would the cure be that it would be impossible to say if the person ever had the disease. No smarting attends its use, and after the first application itching is practically at an end. Also in that form of prickly heat resembling urticaria it effects a perfect cure, and the powder used once or twice a week, as described, will keep the skin in a perfect condition."

PUS IN HOSPITALS.

LATELY, M. Nepveu, head of the laboratory at La Pitié, has presented an account of his researches in this direction to the Biological Society. A square meter of one of the surgical wards having been washed for the first time in two years, the liquid pressed from the sponge was carefully examined immediately afterward. It was found to contain micrococci in great numbers (fifty or sixty in the field of the microscope), some micro-bacteria, a small number of epithelial cells, some pus globules and red globules, and some irregular black masses and ovoid bodies of an unknown nature. Every precaution was taken to prevent error, the sponge being new, and previously washed in distilled water. These facts give some idea of the elements constituting what has been called "nosocomial poison," and enable us to see how the germs of a great number of diseases exist in the air of hospitals, and render them liable to become centers of infection. Although in a lesser degree, the same conditions may prevail in civil practice, especially in winter, when patients are long confined to beds surrounded by curtains and insufficiently ventilated.

OXIDE OF ZINC IN DIARRHŒA.

DR. BONAMY, of Nantes, relates, in the *Bull. de Therap.*, some cases confirmatory of the great and speedy utility of oxide of zinc in obstinate diarrhœa that has resisted various other remedies. He employs the formula recommended by Prof. Gubler, who first used the remedy for this purpose, viz., three grammes and a half (fifty-three grains) of the oxide, combined with half a gramme (eight grains) of bicarbonate of soda, and divided into three or four doses, one to be taken every three hours. The addition of the soda prevents the production of vomiting by the zinc.

ELIMINATION OF LEAD IN SATURNINE PARALYSIS.

PROFESSOR SEMMOLA, of Naples, has recently published an account of six cases of paralysis from lead-poisoning in which he has effected a rapid cure by inducing the elimination of the lead, chiefly in the urine, by the agency of the continued current applied in the region of the ganglionic nervous centers, without any attention being directed to the paralyzed parts themselves. On the second day of the treatment lead begins to appear in the urine, and increases in quantity as amendment progresses. In from fifteen to twenty days the blue line on the gums disappeared, and in two or three months the paralysis was entirely cured, without any other means being employed. Prof. Semmola claims this mode of employing electricity in these cases as entirely his own, former applications having been directed to the local stimulation of the nerves and muscles of the paralyzed parts—a procedure that does not enter into his plan of treatment, which entirely consists in increasing the action of the eliminating organs.—*Med. and Surg. Reporter.*

JAUNDICE FROM PORK AND BEANS.

A SEVERE epidemic of jaundice broke out in a portion of the German army a few years ago. The staff surgeon, Dr. Kohnhorn, proved that the cause of the epidemic was a preponderance, in the rations of the affected regiment, of pork and dried peas and beans; and also that the number of cases in the battalions attacked was directly proportional to the quantity of these articles of food supplied to the men.

A cavalry regiment of 1,240 men, which was able to obtain occasional supplies of fresh vegetables and potatoes, and especially salad made with dandelion (*Leontodon Taraxacum*), had not a single man on the sick-list from jaundice. Dr. Kohnhorn mentions other instances of similar epidemics, and his paper is well worth the perusal of military surgeons. It is found in the *Berliner Klin. Wochenschrift, Feb.*, 1877.

CHAMOMILE FUMES IN HAY FEVER.—Drs. Barnes Brothers, of Illinois, mention a simple remedy which has been used with excellent results by them in a number of cases of hay fever, after all the usual methods of treatment had failed. The remedy is the inhalation of the smoke from burning the flowers of chamomile (*Anthemis nobilis*) The fumes should, of course be brought into contact with every portion of the nasal passages, in order to receive full benefit of the drug. A few coals on a plate, and the flowers dropped on them, is a good way for using it.

NITRIC ACID FOR HOARSENESS.—Dr. W. Handsell Griffiths says that a few drops of nitric acid in a glass of sweetened water, a couple of times daily, will be found an excellent remedy for the hoarseness of singers. One of the largest fees ever received by him—so he says—was for this prescription.—*Southern Medical Record.*

HUMAN GASTRIC JUICE.—M. Ch. Richet.—The quantity of liquid in the stomach has no influence upon its acidity. Wine and alcohol augment the acidity, but sugar diminishes it. The gastric juice is more acid during digestion than at other times.

A NEW DISCOVERER OF ANÆSTHESIA.

THERE is another claimant for the honor of discovering anæsthesia. This announcement will hardly startle the professional mind, thoroughly accustomed as it is to listen to questions of priority. On the ether discovery it is quite a relief to have our thoughts diverted into an entirely new channel. Indeed, for the very novelty of the idea, we willingly ignore, for the present at least, Wells, Morton, and Jackson, and pay our respects to Dr. C. W. Long, of Athens, Georgia, who, Dr. Sims claims,* is the real discoverer of anæsthesia. It is such a matter of congratulation to have this vexed question so definitely settled at last, that we half forgive the modesty of Dr. Long for keeping himself so long in the background. At last, however, he is fortunate in having so distinguished a champion as Dr. Sims to urge his claims to the profession and to the world. The narrator became acquainted with the facts of Long's labors by mere accident.

In October, 1876, Dr. P. A. Wilhite, of Anderson, S. C., came to New York to consult Dr. Sims concerning the health of his daughter. Her case required a surgical operation, and it was necessary for her to take ether, which was given by Dr. Harry Sims. After the operation was over, and while they were waiting to see the patient fully restored from the effects of the anæsthetic, the conversation naturally turned upon the wonders of anæsthesia, when Dr. Wilhite said, "Doctor, I assisted at the first operation ever performed under the influence of ether." Dr. S. said, "But how could this be, when you have never been in Boston, and the first operation ever performed under ether was by Warren, of Boston, in October, in 1846, or, as some claim, by Marcy, of Hartford, in 1846?" Dr. Wilhite then told him that he had assisted Dr. Crawford W. Long, of Georgia, in extirpating a tumor from the neck of Mr. Venable, in March, 1842, while he was completely anæsthetized by the inhalation of sulphuric ether—that Mr. Venable was as profoundly anæsthetized as the patient then lying before them—and he also said that he had assisted Dr. Long to operate on other patients under the influence of ether in 1843 and 1844, while he was a student of medicine in Dr. Long's office. Dr. W. declared that Long was the real and original discoverer of anæsthesia, and he believed he would be so acknowledged if all the facts in the case were fully set forth.

As an item of corroborative history the patient upon whom the operation was performed, having been sworn July, 1849 (seven years after having taken the ether), says:

"In the early part of the year (1842) the young men of Jefferson and the country adjoining were in the habit of inhaling ether for its exhilarating powers, and I inhaled it myself frequently for that purpose, and was very found of its use. While attending the academy, I was frequently in the office of Dr C. W. Long, and having two tumors on the side and rather back of my neck, I several times spoke to him about the propriety of cutting them out, but postponed the operation from time to time. On one occasion, we had some conversation about the probability that the tumors might be cut out while I was under the influence of sulphuric ether, without my experiencing pain, and he proposed operating on me while under its influence. I agreed to have one tumor cut out, and had the operation performed that evening (afternoon), after school was dismissed. This was in the early part of the spring of 1842. I commenced inhaling the ether before the operation was commenced, and continued it until the operation was over. I did not feel the slightest pain from the operation, and could not believe the tumor was removed until it was shown to me. A month or two after this time, Dr. C. W. Long cut out the other tumor situated on the same side of my neck. In this operation, I did not feel the least pain until the last cut was made, when I felt a little pain. In this operation, I stopped inhaling the ether before the operation was finished. I inhaled the ether in both instances from a towel, which was the common method of taking it."

These, then, are in substance the facts of the case as presented by Dr. Sims. Recollecting that Wells, who is generally believed to be the discoverer of anæsthesia, first used his nitrous oxide in 1844, Long apparently antedates him two years and eight months. Morton's anæsthesia with ether being on the 30th of September, 1846, was antedated four years and six months. So says the new history before us. If it had only been written sooner, how much trouble and printer's ink would have been spared? We are afraid, however, that many will not even take the decision of Dr. Sims as final, and will still continue to be disputatious. But it is proposed to compromise the difficulty by asking Congress to vote to each of the families of Long, Wells, Morton, and Jackson the sum of one hundred thousand dollars. As there is not much likelihood that Congress will be in any hurry to take up the discussion, there may still be time and opportunity for a few discoverers to put in their claims. In the meantime it might be eminently proper for those having charge of the monument in Boston to enlarge its inscription surface, that when the roll of honor is finally complete, and the last man shall be satisfied that justice is done, no invidious distinctions shall be made. Then, and not till then, will each believer be able to worship at the particular shrine of his pet idol.—*Medical Record.*

ON THE TEMPORARY PRESENCE IN THE HUMAN BLOOD OF A LARGE NUMBER OF VERY MINUTE RED GLOBULES.—Drs. Lépine and Germont, of Paris, report that, in examining the blood of a patient suffering from carcinoma of the stomach, they were surprised to find a large number of minute pale red globules, two to three thousandths of a millimetre in diameter, and in number about equal to that of the red globules. The little bodies had the contour of microcytes; that is, they were spherical, or nearly so, and not biconcave. Their color was less pronounced than that of the ordinary red globules, so that it required close scrutiny to distinguish them from the little white corpuscles. The blood was obtained in the usual way, that is, by puncture of the finger; it was then deposited upon a glass slide and covered, without the addition of any reagent. Two days later, when the examination was repeated, there was not a single one of the red spherules to be seen, nor could any afterwards be found. In a second case of carcinoma of the stomach, in a patient aged forty-six, an examination of the blood showed that there were vast numbers of the minute red globules which did not have a diameter of quite five thousandths of a millimetre, and equaled in number the red blood corpuscles, while there was a goodly number of red corpuscles, from two and four thousandths of a millimetre, at the extreme limit. Subsequently there were rouleaux of red globules, the smallest having a diameter of five thousandths of a millimetre. There was no notable change in the general symptoms between the two examinations to account for the change in the blood. In this connection reference is made to an article on the same subject by Litten, in the *Berl. Klin. Woch.*, No. 1, 1877, where this temporary microcythemia was noticed in the blood of a man of twenty, who had œdema of the lungs, and also in three anæmic persons, a point which other authors have noticed. In two of these latter cases there was a remarkable change in form of the red globules. To account for such temporary appearances two hypotheses are presented: one, that they are the new formation of a great number of red globules, which are in the process of development into the larger globules; or, that they result from fragmentation of the large red blood globules. The author adheres to the former theory, though as yet it lacks a sufficient amount of evidence in its favor.—*Gazette Méd. de Paris.*

* Discovery of Anæsthesia, by Dr. J. Marion Sims, *Virginia Med. Monthly.*

CAUSE OF PAIN.

IN a paper recently read before the American Medical Association, Dr. S. W. Gross, of Philadelphia, discussed this subject in connection with the following propositions:

1st. That the nervous fluid, as it is called, is precisely similar to, if not positively identical with, the electric or galvanic fluid, modified, of course, by the play of the vital actions which everywhere exists in the organs and tissues through which the nervous fluid circulates. 2d. That the fluid under consideration is generated by the brain, spinal cord, and nervous ganglia, and that the nerves are simply passive cords, ropes, or, so to speak, wires, for the transmission of the nervous fluid. 3d. That what is called pain is due immediately and directly to obstruction to the transmission of the nervous current, thereby causing an accumulation of nervous fluid at the seat of the obstruction. 4th. That pain can take place only in connection with a sound state of the brain and spinal cord, or, in other words, that when these organs are seriously affected there can be no perception of pain or suffering whatever. 5th. That pain is modified or influenced by structure and by the nature of the exciting cause.

DEAFNESS.

DR. S. D. JONES, of Chicago, lately submitted a paper to the American Medical Association on the above subject, an abstract of which was read by Dr. Andrews.

Dr. Jones discussed the practical value arising from the anatomical divisions of the ear, and gave a description of instruments designed for the diagnosis and treatment of ear diseases. The most frequent seat of disease was the middle ear, in consequence of its immediate connection with the throat. Attention was drawn to the propriety of puncturing the drum under certain circumstances. The author believed that there were but few cases of catarrhal deafness which might not be relieved. It was difficult to conceive of such a thing as hereditary deafness.

SKIN GRAFTING.

W. SYMINGTON BROWN, M. D., of Stoneham, Mass., lately reported to the Massachusetts Medical Society a case of skin grafting, and showed the patient, a young woman, who, nearly five years ago, had her entire scalp torn off by her hair being caught in a revolving belt. Although the scalp was immediately replaced, it subsequently shrivelled up, and had to be cut away. During three years subsequent to May, 1873, 2,600 grafts of skin were made upon the patient's head, and now the entire scalp, with the exception of a small space over the left eye, has been healed. The eyelids have thus far remained unhealed, but it is hoped that a plastic operation may be performed upon them after the summer season has passed.

THE BODY IN EXTREME AGE.

DR. ANDREW H. SMITH lately presented to the New York Pathological Society specimens taken from a man aged one hundred and five years. He had been an opium-eater, and when he was ninety years old took one and a half drachm of gum-opium daily. He was exposed on January 28th to a storm, and contracted an attack of congestion of the lungs, which lasted forty-eight hours. From this he partially rallied, but never recovered his usual health. Two weeks before death the right thigh began to enlarge, owing to the formation of an abscess. The aspirator-needle was introduced, and eighteen ounces of pus withdrawn. The patient died on April 3d. At the autopsy the abscess was found to be caused by three cysts, which had suppurated. An elastic tumor was found in the abdomen, which was about the size of a child's head. It contained friable material, closely resembling broken-down hepatic tissue. The right kidney was absent, and in its stead a cystic tumor was noticed. The left kidney was contracted, yet the patient never suffered from any symptoms which indicated renal disease. A cyst existed in the substance of the liver, which contained serum. The heart was fatty, but no valvular disease could be made out. The ribs had changed in structure to such an extent as to be readily cut with scissors. The integument was much softened, and could be readily lacerated.

SINGULAR EXAMPLE OF LEAD POISONING.

DR. ALFORD, the medical officer of health for Taunton, in his last report to his authorities, stated that he had recently investigated an outbreak of lead poisoning in his district. The disease was in most cases of a very marked character, the blue lines on the gums, the colic and other symptoms being unmistakable. The first cases that occurred were in an isolated farmhouse. Repeated visits and analyses of water, preserves, etc., threw no light whatever on their origin; he could find no lead. Then, in sharp succession, a large number of fresh cases were reported to him in various houses, mostly isolated, in the neighborhood, many of which were very severe. Some six or seven families were affected. They all had in common, it appeared, sent their corn to be ground at the same mill. He had visited and inspected this mill, and the origin of all the mischief was at once apparent. On having the millstone raised he found the surface of each stone honeycombed with lead. The millstone being of a very loose nature large spaces occur, which of late, during the illness of the owner, had been filled up by pouring in quantities of molten lead. The first grinding of wheat after the "dressing" contained, no doubt, large quantities of the metal. He at once had the lead removed, but from what he heard this was by no means an uncommon way of repairing millstones. He had, therefore, the more fully reported this case that the public might be aware of a dangerous source of poisoning. He was within the mark in saying that some six or seven families, numbering in all, perhaps, some fifteen or twenty persons, had been almost simultaneously poisoned. There was, according to the *Sanitary Record*, about 10 lbs. of lead upon the surface of the millstone, and the cavities were all filled up with the same metal.

ON THE RELATIVE AGES OF THE SUN AND CERTAIN OF THE FIXED STARS.

By Professor DANIEL KIRKWOOD, of Indiana University.

(Read before the American Philosophical Society, April 6, 1877.)

THE doctrine that the light and heat of the sun are produced by the chemical combination of its elements was very generally accepted till about the middle of the nineteenth century. It has, however, been completely disproved by the labors of Dr. Mayer and Sir William Thomson. The quantity of heat radiated by the sun in a given unit of time has been determined with approximate accuracy. The amount produced by the combustion of a given quantity of coal is also known. From these data it is easily shown that if the sun were a solid globe of coal, and a sufficient supply of oxygen were furnished to support its combustion, the amount of heat resulting from its consumption would be less than that actually emitted within historic times. "Take (in mass equal to the sun's mass) the most energetic chemicals known to us, and in the proper proportion for giving the greatest amount of heat by actual chemical combination; and, so far as we yet know their properties, we cannot see the means of supplying the sun's present waste for even 5,000 years."* The chemical theory is accordingly given up as wholly untenable.

What, then, is the source of solar energy? To this interesting question, in the present state of our knowledge, but one reply is possible. The great law of the conservation of force—one of the most important discoveries in the history of physical science—points at once to a cause which is adequate both in mode and measure. Motion may be transformed into heat, and *vice versa*. The heat produced by the fall of a given quantity of matter upon the sun from the outer limits of the solar system would be 7,000 times greater than that resulting from the combustion of its own weight of coal. In the mechanical theory of solar energy, as advocated by Helmholtz and now generally accepted, the sun's heat is produced by the falling together or condensation of the matter of which its mass is composed. But the rate of solar radiation and also the mechanical equivalent of heat are known. With these as data it may be easily calculated that a contraction of the sun's radius amounting to one mile in 40 years would be sufficient to keep up the present supply of heat. At former epochs, when the volume was greater and the density less, a more rapid contraction was necessary to keep up the supply. If the sun, or rather the solar system originally existed as a nebulous mass, with a radius equal to half the distance of the nearest fixed stars, the total amount of heat generated by contracting to its present dimensions would have kept up a supply, equal to that now dispensed, for about 20 millions of years. This period, it will be observed, includes the entire physical history of the solar system, from Neptune down to Mercury. It must be liable, however, to considerable uncertainty, as it assumes the radiation of heat to have been uniform.

Before attempting a comparison between the ages of the sun and certain of the fixed stars, it should be premised that from the epoch of incipient solidification, or rather of incipient transition from the gaseous to the liquid form, the quantity of motion in the contracting mass, and consequently the amount of radiant heat, must gradually diminish. Many of the nebulæ and some of the fixed stars have not reached this epoch; while the sun, 61 Cygni, and the companion of Sirius, as will be shown hereafter, have probably passed it. Our first comparison will be that of

THE SUN AND ALPHA CENTAURI.

The larger component of the double star Alpha Centauri is of the first magnitude; the smaller one, of the second. The color of both has been described as dark orange. According to Hind,† the system completes a revolution about its centre of gravity in 85 years; the mean distance between the components being 23·49 times the radius of the earth's orbit—somewhat greater than the distance of Uranus from the sun.

Of all the fixed stars whose distances have been measured, Alpha Centauri is the nearest to us. Its annual parallax is $\frac{1}{1,338}$ ths of a second, which corresponds to a distance 7,336 times that of Neptune from the sun: so completely isolated in space is our planetary system.

The apparent magnitude of Alpha Centauri is greater than that of any star in the Northern Hemisphere; and of those south of the equator, but visible in our latitude, Sirius alone surpasses it in splendor. Its mass is nearly the same with that of the sun,‡ while the intrinsic light and heat of the system are nearly three times greater. It may be inferred from these facts that the sun has probably passed the epoch of greatest heat, and that it is further advanced in its physical history, or, in other words, is an older star, than Alpha Centauri.

61 CYGNI

The annual parallax of 61 Cygni is $\frac{1}{6.5}$ ths of a second, which corresponds to a distance 448,000 times that of the earth from the sun. The magnitudes of the components are 5½ and 6; their distance from each other is 45 times the radius of the earth's orbit; their period, about 500 years; and the sum of their masses rather more than one third of the sun's mass. They have the same color—a golden yellow.

The mass of the larger component of 61 Cygni may be taken at one fifth of the sun's mass. According to the estimate of Sir William Herschel, the light of an average star of the first magnitude is 50 times that of a star of the fifth, or about 75 times that of the larger component of 61 Cygni. The intrinsic light of the principal member of Alpha Centauri being twice that of the sun, and the light received from it 75 times that received from A 61 Cygni, we obtain the following relations:

	Sun.	A. 61 Cygni.
Surface (densities equal?)	3	1
Mass	5	1
Intrinsic light	9½	1

These numbers seem to indicate that 61 Cygni is further advanced than the sun in its physical history.

* Tait's Recent Advances in Physical Science, 2d ed., p. 152.

† Monthly Notices of the R. A. S. for January, 1877. These elements differ materially from those previously found.

‡ Hind's recent value is *greater* than the sun's mass, all former estimates *less*.

SIRIUS.

"It has been long acknowledged," says Humboldt, "that of all the brightest luminous fixed stars of heaven, Sirius takes the first and most important place, no less in a chronological point of view than through its historical association with the earliest development of human civilization in the valley of the Nile." The recent discovery of its binary character, together with the determination of its parallax, mass, motion, and constituent elements, have greatly enhanced the interest with which this star is regarded by the scientific public. From the meridian altitudes of Sirius, as observed by Sir Thomas Maclear, at the Cape of Good Hope during the years 1836 and 1837, Dr. Gylden, of Pulkowa, has found its annual parallax to be $\frac{1}{1000}$ths of a second, which corresponds to a distance 1,068,700 times that of the sun from the earth. The light of this star is therefore 16 years in reaching us.

The orbit of this binary system has been computed by Dr. Auwers, who finds the period of revolution to be 49 years and 146 days; the semi-axis major, 37 times the distance of the earth from the sun; and the eccentricity, 0·6148—somewhat greater than that of Fays' comet. The mass of the companion is half that of the principal star; or more accurately, the mass of Sirius is 13·76, and that of the telescopic star, 6·71, the mass of the sun being unity. According to the photometrical experiments of Sir John Herschel, the light received from Sirius exceeds that of Alpha Centauri in the ratio of 25 to 6. Comparing therefore, the distances of two stars, we find the intrinsic light of Sirius to be 98 times that of Alpha Centauri, or 279 times that of the sun. The relative quantity of heat emitted by the different bodies may be assumed to have the same ratio.

But while the mass and distance of Sirius have been ascertained within moderate limits of error, the degree of its condensation, as compared with that of the sun, is still undetermined. On the hypothesis of equal density the light emitted from the sun would be but $\frac{1}{98}$th part of that radiated from an equal portion of the star's surface. But, if equal areas of the two bodies afford equal quantities of light, then the volume of Sirius is 4,661 times that of the sun, and the mean density of the latter is 333 times that of the former. It seems probable, therefore, that the principal component has still chiefly, if not entirely, a gaseous constitution.

As the light of Sirius, according to Sir John Herschel, is 324 times that of an average star of the sixth magnitude, and as the satellite discovered by Clarke is of the ninth or tenth magnitude, the light of the latter must be much less than one thousandth part of that received from the principal star. But according to Auwers the mass of the less component is equal to half that of the greater. Is it possible to explain these remarkable facts on the theory that the two bodies had a simultaneous origin in the same nebula, or has their present proximity resulted from the proper motions of two originally independent stars?

The conclusions apparently sustained by the facts here considered may be summarized as follows:

(1.) The history of the solar system is comprised within twenty or thirty millions of years.

(2.) From the fact that the larger component of Alpha Centauri radiates twice as much light as the sun while the mass of the former is *less* than that of the latter, we infer the probability that our solar system is the more advanced in its physical history.

(3.) 61 Cygni seems to have reached a greater degree of condensation than the sun, since, on the hypothesis of equal density, the surface of the larger member is one third that of the sun, while the intrinsic light is less than one ninth.

(4.) The companion of Sirius appears to have reached a stage of greater maturity than the sun, while the contrary seems to be true in regard to the principal star.

Bloomington, Indiana, March 26, 1877.

ON CATASTROPHISM.

By CLARENCE KING.

(Continued from SUPPLEMENT No. 80.)

It is unnecessary to repeat here the well-known views of Lyell. How far biologists have learned to lean on his uniformitarian conclusions may be seen from the following quotation from Haeckel, "History of Creation," vol. I., pages 127, 128, 129: "He (Lyell) demonstrated that those changes of the earth's surface, which are still taking place before our eyes, are perfectly sufficient to explain everything we know of the development of the earth's crust in general, and that it is superfluous and useless to seek for mysterious causes in inexplicable revolutions. He showed that we need only have recourse to the hypothesis of exceedingly long periods of time, in order to explain the formation of the crust of the earth in the simplest and most natural manner, by the means of the very same causes which are still active. Many geologists had previously imagined that the highest chains of mountains which rise on the surface of the earth could owe their origin only to enormous revolutions, transforming a great part of the earth's surface, especially to colossal volcanic eruptions. Such chains of mountains as those of the Alps or the Cordilleras were believed to have arisen direct from the fiery fluid of the interior of the earth through an enormous chasm in the broken earth. Lyell, on the other hand, showed that he can explain the formation of such enormous chains of mountains quite naturally by the same slow and imperceptible risings and depressions of the earth's surface which are still continually taking place, and the causes of which are by no means miraculous. Although these depressions and risings may perhaps amount only to a few inches, or at most a few feet, in the course of a century, still, in the course of some millions of years, they are perfectly sufficient to raise up the highest chains of mountains without the aid of mysterious and incomprehensible revolutions. . . . We have long known, even from the structure of the stratified crust of the earth alone, that its origin and the formation of neptunic rocks from water, must have taken at least several millions of years. From a strictly philosophical point of view, it makes no difference whether we hypothetically assume for this process ten millions or ten thousand billions of years. Before us and behind us lies eternity."

This is even bolder than Hutton, who says: "I take things as I find them at present; and from these I reason as regards that which must have been. . . . A theory, therefore, which is limited to the actual constitution of this earth, cannot be allowed to proceed one step beyond the present order of things."

The successive hypotheses which, linked together, form the chain of Evolution are, first, the nebular hypothesis; second, spontaneous generation; third, Natural Selection. It is only with the last that geology has intimate relation. The general theory of a derivative genesis, or the descent of all organisms by the various modes of reproduction from one or a few primitive types which came into existence by spontaneous generation, was believed long before the Darwinian theory was advanced. Darwin's great contribution was the *modus operandi* of derivative genesis. It was a mode of accounting for the infinite branching out and differentiation of the complex forms of life from the primitive germs. His theory is Natural Selection, or the survival of the fittest, a doctrine which, left where Darwin leaves it, has its very roots in Uniformitarianism.

Analyzed into its component parts, Natural Selection resolves, as is well known, into two laws, Hereditivity and Adaptivity; first, the power on the part of organisms to transmit to offspring their own complex structure down to the minutest details, and secondly, the power by slight alterations on the part of all individuals to vary slightly in order to bring themselves into harmony with a changed environment. When we bring geology into contact with Darwinism, it is evident that Hereditivity is out of the domain of our inquiry; it is not the engine of change, it is the conservator of the past; but the companion law of Adaptivity, or the accommodation to circumstances, is one which depends half upon the organism and half upon the environment; half upon the vital interior, half upon the pressure which the environment brings to bear upon it. Now, environment, as conclusively shown by biologists, is a twofold thing, a series of complicated relationships with cotemporaneous life, but besides, with the general inorganic surrounding, involving climate and position upon the globe. Preoccupied with the strictly biological environment, namely, the intricate relation of dependence of any species upon some of its surrounding species, biologists have signally failed to study the power and influence of the inorganic or geologic environment. The actual limits of the influence of physical conditions on life are practically unknown. In America, more than in Europe, this branch of inquiry has begun to attract notice, but it is yet in its swaddling clothes. It has lain little and weak from inanition, while the favorite child, Natural Selection, has been fed into a plethoric, overgrown monster. Darwin, Wallace, Haeckel, and the other devoted students of Natural Selection, have brought to light the most astonishing complex struggle for existence everywhere progressing; the fiercest battle for life and for subsistence, for standing room, for breath. Species gain, others lose, some go down to annihilation. In this battle they see adequate cause for all the great, highly organized products of the millions of years since life began. From their logic, you and I are conquerors who have mounted to manhood by treading out the life of infinite generations. We are what we are because this brain and this body form the most effective fighting machine the dice-box of ages has thrown.

From their conclusions and philosophy let us turn, but with no revolt of prejudice, no rebound of a happier intuition, for this is a question of science. Those who defend the stronghold of Natural Selection are impregnable to the assaults of feeling. They are dislodged only by the solid projectiles of fact, and to facts cast in the mould of nature they count it no dishonor to surrender. If, as I have said, the evolution and power of environment have been singularly neglected studies; if biologists have allowed the splendor of their achievements within the province of life to blind them to the working of that other and no less important side of the problem, what then is the general relation in time and space of the inorganic environment to life?

Let us first acknowledge frankly that the present and later part of the Quaternary period are Uniformitarian, and that the changes going on in organic life now do obey the great law of survival of the fittest, and that if the Uniformitarians were true in making of the past a mere infinite projection of the present, then the biologists would have based their theories on a solid foundation, and my protest would have no weight. Let us go further, and cordially admit that in all periods of uniformity the progress of life would adjust itself to its surroundings, and the war of competitive extermination become the dominant engine of change and development. This is giving full credit to the greatness of the biological result, and simply asserts that they who achieved it are sound as far as the analogy of present uniformity may be permitted to go. But uniformity has not been the sole law; it has, as we have seen, been often broken by catastrophes—that is, by accelerated rate of change. Rapid physical change has been, it seems to me, the more important of the two conditions of the past, the one whose influence will at last prove to have been the dominant one in life-change.

IMPORTANCE OF ENVIRONMENT.

Has environment, with all the catastrophic changes, been merely passive as regards life? It has either had no effect, or has restrained the progress of evolution, or has advanced it, or its influence has been as varied as its own history—now by the development of favoring conditions accelerating vital progress, now suddenly exterminating on a vast scale, again urging evolution forward, again leaving lapses of calm in which species took the matter into their own hands and worked out their own destiny. It is only through rapid movements of the crusts and sudden climatic changes, due either to terrestrial or cosmical causes, that environment can have seriously interfered with the evolution of life. These effects would, I conceive, be first, extermination: secondly, destruction of the biological equilibrium, thus violating natural selection; and thirdly, rapid morphological change on the part of plastic species. When catastrophic change burst in upon the ages of uniformity, and sounded in the ear of every living thing the words "change or die," plasticity became the sole principle of salvation. Plasticity, then, is that quality which, in suddenly enforced physical change, is the key to survival and prosperity. And the survival of the plastic, that is of the rapidly and healthily modifiable during periods when terrestrial revolution offers to species the rigorous dilemma of prodigious change or certain death, is a widely different principle from the survival of the fittest in a general biological battle during terrestrial uniformity. In one case it is an accommodation between the individual organism and inorganic environment, in which the most yielding and plastic lives. In the other it is a Malthusian death struggle, in which only the victor survives. At the end of a period of Uniformitarian conditions, the Malthusian conqueror, being the fittest, would have won the prize of survival and ascendency. Suppose now an interval of accelerated change. At the end only the most plastic would have deviated from their late forms and reached the point of successful adaptation, which is survival in health. Whatever change takes place by natural selection in Uniformitarian ages, according to Darwin, advances by spontaneous, aimless sporting, and the survival of those varieties best adapted to surrounding conditions, and of these conditions the biological relations are by far the most important of all. By that means, and by that alone, it is asserted, species came into existence, and inferentially all the other forms from first to last. This is the gospel of chance.

If the out door facts of American geology shall be admitted to bear me out in my assertion of catastrophes, and if the epochs of maximum vital change do, as I hold, coincide with the epochs of catastrophes, then that coincidence should be directly determinable in the field. I confidently assert that no American geologist will be able to disprove the law that in the past every one of the great breaks in the column of life coincide with datum points of catastrophe. It remains to be determined how far this coincidence is the expression of environmental cause, responded to in terms of vital effect.

From a comparison of the list and character of geological changes in America with those mysterious lines across which no species march, I feel warranted in harboring the belief that catastrophe was an integral part of the cause; changed life, the effect. Biology is accustomed to explain the cause of a great gap like that which divides the Palæozoic and Mesozoic life by an admission that the Palæozoic forms ceased to live, but that the succeeding changed forms at the beginning of the Mesozoic were not the local progeny; greatly modified by catastrophic change, but merely immigrants from some other conveniently assumed country. They succeed in rendering this highly probable, if not certain, in many instances. But they are estopped from always advancing this migration theory. Greek art was fond of decorating the friezes of its sacred edifices with the spirited form of the horse. Times change; around the new temple of evolution the proudest ornament is that strange procession of fossil horse skeletons, among whose captivating splint-bones and general anatomy may be descried the profiles of Huxley and Marsh. Those two authorities, whose knowledge we may not dispute, assert that the American genealogy of the horse is the most perfect demonstrative proof of derivative genesis ever presented. Descent they consider proved, but the fossil jaws are utterly silent as to what the cause of the evolution may have been.

I have studied the country from which these bones came, and am able to make this suggestive geological commentary. Between each two successive forms of the horse there was a catastrophe which seriously altered the climate and configuration of the whole region in which these animals lived. Huxley and Marsh assert that the bones prove descent. My own work proves that each new modification succeeded a catastrophe. And the almost universality of such coincidences is to my mind warrant for the anticipation, that not very far in the future it may be seen that the evolution of environment has been the major cause of the evolution of life; that a mere Malthusian struggle was not the author and finisher of evolution; but that He who brought to bear that mysterious energy we call life upon primeval matter, bestowed at the same time a power of development by change, arranging that the interaction of energy and matter which make up environment should, from time to time, burst in upon the current of life and sweep it onward and upward to ever higher and better manifestations. Moments of great catastrophe, thus translated into the language of life, become moments of creation, when out of plastic organisms something newer and nobler is called into being.

BUILDING MATERIALS PRODUCED IN MAINE.

IT has been stated on scientific authority that there is granite enough in Maine to build all the cities of the world. The granite formation is certainly an extensive one, and its varieties traverse the larger portions of the State; blocks of immense size have been split out, some weighing more than 100 tons each. In quality the granite quarried is of fine grain, beautiful in color, and very durable. The facilities for quarrying are unequalled, and the economical advantages of shipment cannot be surpassed, most of the quarries being on navigable waters. The principal localities of the granite-quarrying are Biddeford, Kennecunk, York, Newfield, Waterford, North Yarmouth, Brunswick, Phipsburg, Hallowell, Augusta, Jay, Wiscasset, Edgcomb, Friendship, Mount Waldi, and Musquito; mountain quarries on the Penobscot; Spruce Head (South Thomaston), Clark's Island (St. George), Fox and Hurricane Island (Vinal Haven), Dix Island (Muscle Ridge Plantation), Frankfort, Blue Hill, Brookville, Deer Isle, Sullivan, Sedgwick, Gouldsbow, Mount Desert, Calais, and other places, all of which can furnish no lack of materials for building or other purposes, and whose supplies are seemingly inexhaustible. Most of the quarries are on the coast, the principal ones being in Knox and Lincoln counties. These quarries are located mainly on Fox, Hurricane, Dix, and Clark Islands, the principal companies being the Bodwell Granite Company, which owns no less than twelve quarries, and gives employment to not less than 1,200 men; the Dix Island Company, which has employed some 800 men or more; the Clark's Island Company, which employs over three hundred men, and the Hurricane Granite Company, which has a force of 100 men or more. From the quarries of the companies the stone for the new War and Navy Department buildings has been furnished, as well as for other public structures in various parts of the country. The stone is all hewn into proper shape after being taken from the quarry, cut to its proper dimensions to fit into its place in the building, then boxed and hooped, and shipped to its destination. The Hallowell Granite Company also does an immense business, employing a force of nearly 1,000 men, and furnished the stone for the new State House, Albany. There are other smaller companies also engaged in extensive operations. At Sullivan immense numbers of paving stones are got out, which are shipped to Boston, New York, and southern ports. It will thus be seen that granite-quarrying of itself affords a revenue of increasing wealth.

In Aroostook county is to be found a splendid statuary marble, distributed along the Penobscot Belt, running across the northern part of the State. The marble found thus far is considered better adapted for building than for ornamental purposes. It has been discovered in great abundance, and few quarries have been opened and worked. It has been found at Sydney, Camden, Hope, Thomaston, and Machias Port. A very good verd-antique marble has been found at Deer Isle, where it is worked with considerable profit. At Lubec a new company commenced quarrying about two years ago.

Roofing slate is found in Maine in immense quantities, and of a superior character in color, grain, and cleavage. The principal belt extends from the Kennebec to the Penobscot River, a distance of eighty miles or more. Instances are shown where slate has been slit into slabs of several feet square; most of it is of such a quality and formation as to be easily made into tables, black boards, writing slates, and

slate pencils. The principal quarries are at present located in Piscataquis county, which supply an immense amount of roofing slate for the New England market. In Scarborough a very good roofing slate is manufactured. Some of the Piscataquis quarrying companies marbleize their slates, and the slate industry is increasing in magnitude yearly.

The clays to be found furnish material for an immense number of bricks, the yards for the manufacture of which are not confined to the enormous supplies along the coast, but find an abundance in the river valleys, including an ample supply of wood. This industry has become an important as well as a successful one. In 1870, Maine stood as the 17th State in the manufacture of bricks, the value of that production from 110 yards being $405,833. Three years later there were 93 brick yards, giving employment to 917 hands, and manufacturing 71,549,000 bricks, with a total value of $520,574. The market for Maine bricks is in the State, Massachusetts, and the southern ports. They can be produced cheaper in Maine than in Massachusetts. The manufacture of lumber is one of the vital industries of Maine. It is a business which, either directly or indirectly, affects numerous other industries, as well as the prosperity of a large number of towns. There is no other kind of productive industry which so many carry on as the manufacture of lumber. The returns are imperfect, but, such as they are, a fair idea may be obtained of the magnitude of the business. In 1874 returns from 339 saw-mills gave a total capital of $4,055,000; steam power, 1,192 horse; water power, 15,724 horse; production of long lumber, 344,406,000 feet; production of short lumber, 60,961,000 feet; value of production, $5,184,445; hands employed, 4,579; wages, £1,663,556. With these data the following estimate has been made of the total number of saw-mills in the State, and the aggregate result for the year, which are as follows:—Total number of saw-mills, 1,109; capital, $7,629,442; steam power, 3,403 horse; water power, 41,383 horse; long lumber manufactured, 667,420,000 feet; short lumber, 72,405,000 feet; value of production including shooks, staves, headings, etc., $2,851,000. It will be borne in mind that this only professes to be an approximate estimate. It has been prophesied that the forests are decreasing to such an extent that in from five to ten years the supply of lumber will become exhausted. It is very true that for several years, what with the lumberman's axe and the destruction of acres of timber lands by fire, the forests have diminished in extent; it is also true that for as many years the same prophecy has been made, and yet Maine still continues to produce an average yearly product of lumber of some 600,000,000 or 700,000,000 feet. From such data as can be had, it seems, although there is a great scarcity of pine, the forest area does not appear to diminish to an extent to cause apprehension that in the next decade the lumber supply will be entirely exhausted. It is estimated in the United States report by the Commissioner of Agriculture for the year 1872, that Maine has 5,835,058 acres in farms, while her area includes 22,400,000 acres of land and water. "In Maine," says this authority, "scarcely more than one-fourth of the area is in farms, the remaining land being covered generally with forest growths, though culled of valuable timber. For over half a century the destruction of our woodland has been in progress, but with new growth, notwithstanding the annual diminution of timber lands, the destruction must be retarded, so that it looks as if the forest area would not be stripped of all its merchantable timber for at least fifty years.—*London Building News.*

LITHOGRAPHIC STONE SUPPLY.

WE take the following interesting extract from the official report of Colonel J. M. Wilson, United States Consul at Nuremberg, Bavaria:

Under the head of "manufactures," I may mention an industry of almost universal interest. I refer to the lithographic stone quarries of Solenhofen, in this consulate. Not having specially referred to these remarkable mines in any previous report, I will now give them more than a passing notice, in the belief that it will not only be desirable matter for the "Commercial Relations," but interesting to the general reader.

I visited the quarries personally, and thoroughly inspected them. I was courteously shown through the different properties.

The exportation of this article to the United States is principally confined to two companies. I made close and minute inquiries relative to the production, manipulation, etc., of the stones, and have the honor to transmit herewith the result of my investigation.

The lithographic stone quarries are located upon a table land on the summit (nearly 3,000 feet above the level of the sea) of a high range of hills running through the town of Solenhofen, situated on the right bank of the little river Altmühl (old mill,) a branch of the Danube. It adjoins the town of Pappenheim, where may be seen the ruins of the old and the new castle of the once famous counts of that name, and a very picturesque surrounding country. The quarries require no drainage. Water never remains long in them, and there are no natural springs. The stone is of oölitic formation, (Jura limestone;) night work and the expense and annoyance of pumping being therefore dispensable. The quarries are only worked in the daytime, and with only light expense.

On first beholding these quarries from a distance, one is singularly impressed. It is not unlike the formation of the ant hill or the den of the prairie dogs in our far western territories. To explain: the miners here first remove some five or six feet of surface earth before coming to the lithographic stone strata. The earth is removed and dumped in a circle, the size of the contemplated quarry. After the marketable stone is reached, probably two-thirds of the quarry consists of dirt and refuge stone in thin strata. This has all to be drawn out and heaped upon the top of the pile accumulated on the border of the quarry, so that by the time an excavation of forty feet is reached the earth and stone above the ground have risen to an equal height, thereby giving the quarry an appearance of greater depth than it actually has.

The manner of removing the refuse matter struck me as distinctly primitive, if not comical. It was drawn from the bottom of the quarry to the very top of the artificial heights by the use of horse power and quaint little carts capable of being drawn in a three foot passage. The body of the cart was a little box holding about a bushel, and this when filled is drawn through cañons only sufficiently wide for a horse to pass. Under the circumstances the load is quite sufficient for the beast. The teamsters employed are generally old men or young boys, such help as is unsuited for the other more important work.

There being plenty of lumber at hand and a surplus of engineering talent in the country, it would seem that some contrivance might be made whereby the work could be expedited and a vast amount of labor saved. The slowness and deliberation with which everything moves would be quite out of the question with the average American producer.

In answer to some inquiries, I was told that this peculiar business could not be hurried; that the employment of labor saving apparatus, such as machinery, etc., had been found to be impracticable; that a plenty of human muscle, male and female, was available, and was far more desirable; that the proprietors are generally independent, and appreciate the value of their property, and saw no reason for haste, especially when they believe it would not pay.

The lithographic stone runs in strata from 5 to 50 feet deep from the surface, where it is found in thin layers from 1 inch to 1 foot thick. It is not usually found thicker than 3 inches. The quantity of earth that has to be removed from the surface before reaching the first stratum varies from 5 to 25 feet. The quarries are seldom worked more than 40 feet deep, nor does the lithographic stone ever appear in massive veins. When it is reached it is found stratified and interlaid with earth or common stone, or both.

About 25 per cent. of the lithographic stones broken are fit for use. The other 75 per cent. may be considered as refuse or waste; worse than worthless, for it is attended with the expense of carting away.

Some regard only the smallest portion of stones secured as fit for lithographic purposes, hardly 10 per cent.; the other 90 per cent. furnishes building material, such as tiles, paving stones, large slabs for tables and counters for public houses, offices, tanneries, glass factories, floors for fire-proof buildings, etc. A good quarry furnishes 20 per cent. saleable material and 80 per cent. waste. In "saleable material" lithographic stones as well as all other productions are included.

Of lithographic stones, they produce the "blue gray" (the best and most expensive) and yellow or cream-colored stones, and the quarries furnish two qualities of each color, namely: stones polished on one side only, and those polished on both sides; and according to their condition the qualities are *prima*, *secunda*, and *tertia*.

About 15 per cent. of the stones are doubly polished, the other 85 per cent. are singly polished. To one *prima* they find about three *secunda* and four *tertia*.

For the United States, the blue gray *prima* doubly polished are only in demand, being the highest priced and most select of all the production; hence these stones are always in demand.

The manufacturers represent that if the consumers in the United States would be served better, *i.e.*, quicker, they must consent to take also the yellow stones, of which very many of larger dimensions are obtained, especially in *secunda*. In general, the production of large stones keeps pace with the consumption. Smaller stones are always plentiful.

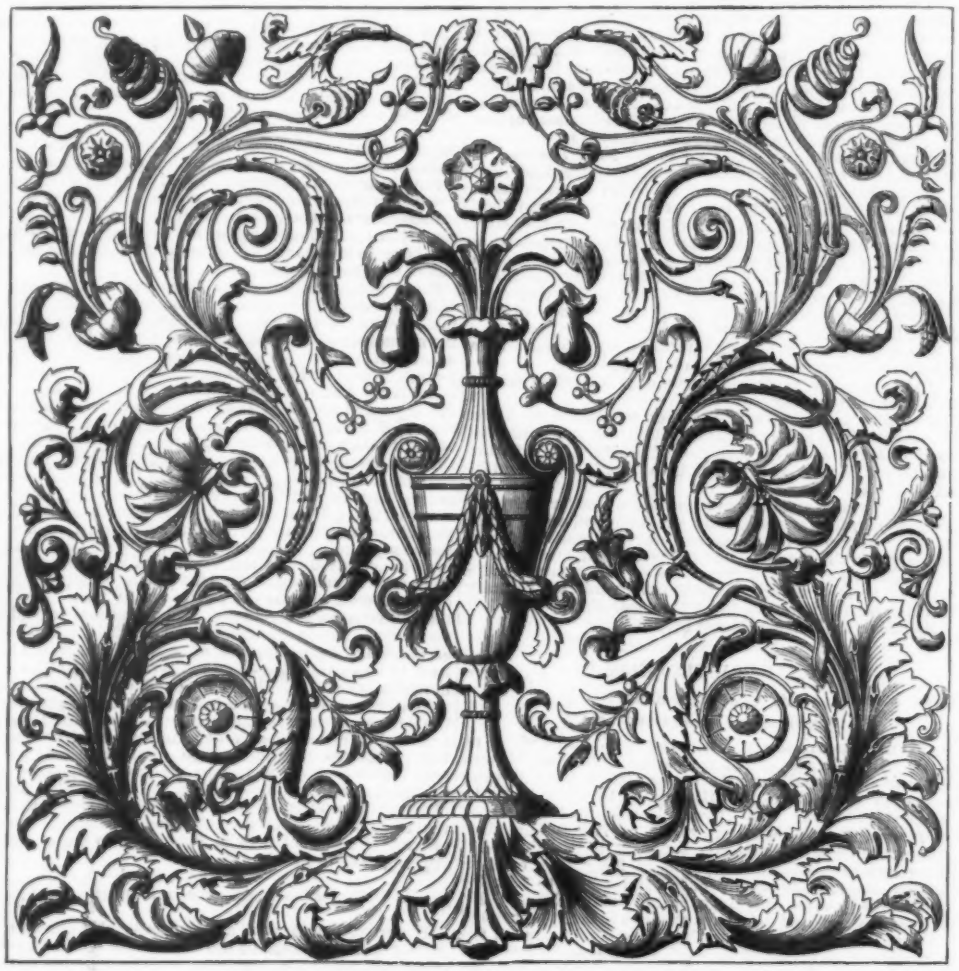
The lithographic stones alone would not pay the expense of quarrying, were it not for the other valuable stones that lie concealed under the strata, and in which the chief wealth and resources of a good quarry lie. They consist of a very hard kind of stone, imperishable by weather and impervious to water, and resist the heat of fire more than ordinary stone. This species of the lithographic stone is found most desirable, and is in much demand for slabs for paving corridors, pavements, fancy floors, and it is also used for water troughs, fountains, and other aquatic purposes, and also for external house facings; ornaments, floors for ten pin alleys, and like purposes. Of the lithographic stones proper, such a second quality, or yellow *secunda*, much is consumed for building material, though used almost exclusively in Germany and Austria. However, it attracts and retains moisture too much to be suitable for the inner walls of dwelling houses. It is largely sought after for paving plates for malt floors, (Malzkeimböden.) It is a well established fact that nothing has been found equal to this stone for this particular purpose. For this it secured the silver medal at the brewery exhibition of Hagenau in 1874. There is no doubt that the Bavarian breweries are, in a measure, indebted for the fame of their beer to these malt floors, *i.e.*, the malt produced upon them. It is presumed these paving slabs would be of great use in our south and southwestern States, for beer and wine cellars, where nature has not provided for such suitable ones.

The stones used only for lithographic purposes are cut and dressed to size and thickness in the quarries, as large as the slab found and as the dimensions will admit. They vary in size from 4 inches square to 12 feet, but 60 inches by 40 may be considered among the largest, and such even are seldom found or required. In one store-house I was pleased to observe some extra fine ones of 10 or 12 feet square, designed for our Centennial Philadelphia Exhibition. They are nearly all broken in the quarries with the ordinary implements, such as pick, wedge and hammer. Very few are sawed. As above mentioned, they are all polished—some on one side, others on both. This takes place in the workshops. Machinery cannot be used to advantage in polishing, consequently all have to be finished by hand work, which is done by laying one slab upon another, with a free use of water and sand between them. The top stone is then propelled with a moderate and uniform motion, backward and forward, until an even surface is produced by the friction. The requisite granulation is secured with the assistance of different grades of sand, the stones being made finer or coarser to suit the trade, or the taste or intention of the artist. Great care is required in this mode of preparation to keep the granulation uniform and the surface free from scratches.

Crude stones are never sent away, as there would be too much risk attending the finishing of the same, besides costing too much for cartage and freight.

In one establishment only, Fischer & Kluge, is machinery propelled by steam power, and this is only used for sawing (splitting apart) the thicker slabs. The machine is a clumsy affair, consisting of a frame-work with five saws arranged in form of a parallelogram, the saws working horizontally. Five slabs of about 4 by 6 feet, and 6 or more inches thick, are placed upright, *i.e.*, edgewise in the machine, where they are held perfectly true and firm. The saws are arranged in parallel form, about a foot apart. They have no teeth, and consist of plates of steel about 12 feet long, 6 inches wide, and ¼ of an inch thick. The sawing is accomplished by friction alone. The machine supplies the steel plates with a constant dripping of water and a sharp quartz sand, and the backward and forward motion of the saws in one and one-half hour's time literally wears through the stones, leaving a true and smooth surface.

The manner of manipulating the stones for market in the workshops is interesting. The stone being a sort of calcareous slate, porous, yet brittle, it readily yields to the wishes of the artisan. An experienced hand will take a slab of any dimensions from 1 to 4 inches in thickness and, with a little sharp-pointed hammer, will break the stone as easily and more accurately than if the same were so much common chalk. For example, a plate 2 inches thick was used. The artist took his square and first drew lines, such as scrolls, fancy figures, etc. He then took the hammer and passed over the lines with a succession of light, sharp taps until he had reached the end of his lines; then the stone



PANEL ORNAMENT DESIGNED BY J. BORMANN, AND MANUFACTURED IN THE ART IRON WORKS OF DANKBERG BROTHERS, BERLIN.—(*From the Workshop.*)

dropped apart of its own weight and with astonishing evenness, the border requiring very little dressing and polishing to make it exactly as required. While these stones are conceded to the best yet discovered for lithographic purposes, even these vary much in quality, all the strata not being equally good. Some are too soft, while others are rendered unfit for use by the presence of chalk, flaws and veins, and fossil remains. It not unfrequently happens that the fossils found imbedded in the stones are the remains of fish, plants, insects, and crabs, intermixed with the bones of no less than seven distinct species of that extraordinary extinct reptile, the pterodactyle, or flying lizard, whose varied organs fitted it alike for earth, air, or water.

The greatest market for lithographic stones is Germany; next in order come France, England, United States, Austria, Switzerland, Russia, etc. It is claimed that the productiveness for the future is secured for hundreds of years. Not more than one hectare (about 2½ English acres) is at present worked annually, while the quarries, including the valleys below, where the stones are already washed out, contain 1,150 hectares. They are situated between 28° 35' and 28° 42' east longitude and 48° 52' and 48° 55' north latitude, and 940 meters (2,800 feet) above the level of the sea.

Strictly speaking, the area of the quarries covers only 840 hectares Of these, the firm of Fischer & Kluge own 23 hectares and the Solenhofen Actien Verein 129 hectares. The balance is divided among about two hundred and fifty proprietors, leaving an average of about 2·7 hectares to each of the small proprietors. Of very many of the small owners, the above-named firms purchase their products either in a crude or prepared condition, and so bring them into the trade.

It is claimed that, up to this day, no lithographic material has been discovered even approximating the Solenhofen stone in quality. The next best found are the stones of Montdardier, department Gard, in France; although their quality was not sufficiently good to enable them to receive the state prize of 30.000 francs which was offered by the Emperor Napoleon III. for the discovery of lithographic stones similar to those of Solenhofen.

In the mineral cabinet of the Solenhofen Actien Verein, I noticed specimens of lithographic stones from St. Remo, Oneglia, and Casale, Upper Italy; Chatillon de Michaille, department de l'Aisne; Medue, department Lozère; St. Antoine, department Tarn and Garonne; Montdardier, department Gar; Crey, department Isère; Cerein, department de l'Ain, in *France*.

Spain.—Near Anguelas del Petregal.
Canada.—From the vicinity of Mormosa
Polonia.—Near Bezozowska.
Austria.—Near Dornbion, Vorarlberg.
German Empire.—Remich on the Moselle, Saalfeld, and Doeschnitz, in Thuringia.
Servia.—Near Waljewo.
Switzerland—Near Geneva and Plötzberg, near Zurich.

Thus it will be seen that by virtue of possessing the lithographic stones, and the inventor of lithography being, at that time, a resident play actor in the theatre at Munich, Bavaria is entitled to the name of the fatherland of lithography. The quarries were discovered in 1611, and from that time to the time of the invention of lithography, in 1796, were only worked for building purposes; but at this time, only stones unsuitable for lithographic purposes are used. In 1796 Herr Sennefelder, a native of Austria, the inventor of lithography, made his first experiments, by etching in the stones, for printing music (printing in relief). In the year 1799 Sennefelder invented the real lithography, or the chemical print, as it is executed up to this day. Until 1825 only very limited use of Sennefelder's invention had been made. Since then, and especially since 1856, lithography has extended itself greatly by the production of the chromographs.

The demand in the United States for these stones has steadily increased during the past decade. In the year 1865, there were shipped to New York, through this consulate, lithographic stones to the value of 6,365.55 florins = $3,546.22. The prices have advanced in proportion to the increase. It is impossible to ascertain, even approximately, the quantity that has already been put into the market, since no export registers thereof have been kept at the mines. Except to the United States of America, there is no way of ascertaining how much has been exported from year to year. My accompanying synopsis of trade will show what amount has been sent to the United States during the current commercial year. It figures at $31,200.64.

For the information furnished, I am indebted largely to the intelligent superintendent of the Messrs. Fischer & Kluge and the Solenhafer Actien Verein, and especially to Mr. Ludwig Rothammel, director of the latter company.

THE GUADALUPE MINE.

"I HAVE traveled many lands, and have seen much of the world's most wonderful and beautiful scenery, but nowhere have I ever beheld so rare a gem as this." Such was the remark of Mr. Hastings, a shrewd Yankee, and a wealthy shipping merchant of Boston, whom we met at the residence of Col. B. B. Thayer, at the Guadalupe quicksilver mine, in this county, a day or two since. And such, we doubt not, was his honest conviction.

But few of our citizens are probably aware of the remarkable improvements and valuable developments which have been made upon this fine mining property within the last two and a half years—since it passed under the management of the present superintendent; and but few are doubtless prepared to believe that the sum of $1,000,000 has been expended upon the property during that period—in the construction of new hoisting and reduction works, storehouses, offices, and miners' cabins; in improving and beautifying the grounds, and in the development of the mine.

BRIEF HISTORY OF THE MINE.

The Guadalupe was among the first of the early cinnabar discoveries of this State. The mine is located in a wild mountain gorge, on the Guadalupe Creek, in the Santa Cruz range, near where the creek emerges into the valley, and distant from San Jose about twelve miles. It is about three miles in a straight line from the famous New Almaden quicksilver mine, and is a part of the same great cinnabar formation, which may be traced for hundreds of miles along our coast range. The mine was discovered as early as 1846, and has been worked with varying results, subject to intervals of litigious suspensions, ever since. It was never, until recently, regarded as a profitable mine—owing, doubtless, to the crude methods of working it, and the lack of experience and capital to develop it properly.

Sixteen years ago the present month, when the editor of this journal visited the mine for the first and (until now) the last time, he found the facilities for working the mine very imperfect. The old incline was located on the right bank of the creek, and terminated near the first level of the present shaft. The furnaces and condensers were of the old styles, wasting nearly as much quicksilver as they saved, and requiring vastly more fuel than the present furnaces, which are continuous feeders, and waste positively no metal. The property at that time presented a generally unthrifty appearance.

The title to the property—which is a United States patent—having been settled, and the ownership having undergone some important changes, the work of developing the property was undertaken in earnest. Capt. Mayo, who superintended the mine for a number of years, was succeeded by Capt. Brown, and he, after two years of management, by the present superintendent, a man well known throughout the State as a chemist, mining expert, and what was of the most consequence, as a thorough-going business man.

THE FIRST STEP.

Colonel Thayer entered upon his duties in the fall of '74. He saw at once the necessity of confining the creek in a water-tight channel to prevent the flooding of the mine. This was accomplished in a few weeks' time with the labor of 500 hands; and thus was one of the most serious obstacles to the successful working of the mine removed. A new shaft was sunk on the opposite side of the creek from the old incline, and hoisting works were erected which can hardly be excelled by anything of the kind on the Comstock. These works alone cost $150,000. The balance wheel of the mighty engine weighs 22,000 lbs., and other portions of the machinery are of like ponderous character. The structure rests upon the solid rock, and the engine runs with the smoothness and precision of clock-work. The main shaft is divided into three compartments, one of which is used for the great pump which drains the mine, and the others for hoisting the ore and lowering timbers, etc., to the mine.

TO THE LOWER REGIONS.

Stepping upon the cage, in company with Colonel Thayer and his mining superintendent, Captain Williams, at the tap of the bell we were dropped the little matter of 600 feet, or about an eighth of a mile, into the bowels of the earth; thence traversing a tunnel for a distance of several hundred feet to the very heart of the mountain, we came to a solid body of ore, which has been uncovered by a cross-cut for a distance of 220 feet. Here we found a perfect wall for the entire length of the ore matter, as distinct and well defined as any which encases a vein of silver-bearing ore. Of the thickness of the ore body no man knoweth, but that it is a veritable

QUICKSILVER BONANZA

is beyond question, as the developments already made in the lode have amply demonstrated. It will be some months yet before this body of ore can be worked to advantage, as the main shaft has first to be sunk to a greater depth, and the necessary drifts, winzes, stopes, etc., to be constructed. Then we may confidently expect that the product of this mine, which is now 1,000 flasks of quicksilver per month, will be speedily increased to 2,000 or more flasks. Upon the upper levels are large quantities of ore easy of access, from which

THE FURNACES

are now supplied. Other furnaces are soon to be erected to meet the increasing product of the mine. Of those recently constructed by Colonel Thayer, they are the result of many years of experience in the reduction of quicksilver ores, and combine the largest reducing capacity with the minimum of expense.

About the furnaces and works generally perfect order everywhere reigns. The men, of whom there are about 250 employed, are provided with comfortable homes. They are of the best class of miners, the good-for-nothings having been sent adrift. All the mining is done by contract, and thus skill and muscle become at once chief factors in swelling the pay roll.—*San Jose Mercury.*

ENGLISH BANK NOTES.

FEW of the persons who handle Bank of England notes ever think of the amount of labor and ingenuity that is expended on their production. These notes are made from pure white linen cuttings only, never from rags that have been worn. They have been manufactured for nearly 200 years at the same spot—Laverstoke, in Hampshire, and by the same family—the Portals, who are descended from some French Protestant refugees. So carefully is the paper prepared that even the number of dips into the pulp made by each workman is registered on a dial by machinery, and the sheets are carefully counted and booked to each person through whose hands they pass. The printing is done by a most curious process in Mr. Coe's department within the bank building. There is an elaborate arrangement for securing that no note shall be exactly like any other in existence. Consequently there never was a duplicate of a Bank of England note except by forgery. According to the *City Press* the stock of paid notes for seven years is about 94,000,000 in number, and they fill 18,000 boxes, which, if placed side by side, would reach three miles. The notes, placed in a pile, would be eight miles high; or, if joined end to end, would form a ribbon 15,000 miles long; their superficial extent is more than that of Hyde Park; their original value was over £3,000,000,000; and their weight over 112 tons.

CRYOLITE AND ITS USES.

THE commercial importance of this mineral at the present time is so great that a glance at its history will be found to possess much interest. The mineral cryolite—ice stone—has figured in descriptive works on mineralogy for the better part of a century, but until lately it was known to mineralogists only as a rare and curious mineral, possessing no value in the arts. It has been found at Miask, in the Ural Mountains, in limited quantities, but its great source is the west coast of Greenland, where it is procured in immense quantities, the particular locality of the mines being at Ivigtout, on Arsuk Flord, between Julian's Hope and Frederick's. The main deposit here forms a mass, according to reliable authority, six hundred feet in length, and two hundred feet in width, and descending to an unknown depth.

The mineral is quite characteristic and beautiful. It occurs in partially translucent masses of a snowy white color, having very much the appearance of snow ice (whence its name, from the Greek *kryos*, meaning ice), and is frequently associated with galena, blende, pyrites (iron and copper), and spathic iron ore. The chemical constitution of the mineral, fluoride of sodium and aluminium, is so peculiar as to have attracted the attention of chemists as long ago as 1850, as a possible profitable source of soda, and, in that year, a well-known Danish chemist, Julius Thomsen, discovered a cheap method of rendering cryolite available for the manufacture of soda and alum. Since that time, the cryolite industry has grown into such proportions that many thousand tons of the mineral are annually consumed. In this country, the Pennsylvania Salt Manufacturing Company, at Natrona, Penn., has a large establishment, at which enormous quantities of cryolite products are turned out annually.

Without entering into details, it may be stated that the utilization of cryolite depends upon Thomsen's observation, that the mineral may be completely decomposed by treatment with lime, either in the wet or dry way, the products of this treatment being, generally speaking, caustic soda, aluminate of soda, and fluoride of calcium. The case with which this decomposition can be effected, and the notable percentage (35 per cent.) of soda which the mineral thus yields up, renders it a very valuable commercial source of soda and its compounds. The alumina which it contains is likewise extensively utilized for the production of alum salts. Where the dry process is employed, the cryolite is dried, ground to a fine powder and mixed with slaked lime, or with pulverized chalk, in such proportions that for each equivalent of cryolite there shall be about six of lime. This mixture is then calcined in a furnace at a dull red heat—not sufficient, however, to fuse it. After a charge has cooled, it is lixiviated, and the dissolved soda and aluminate of soda drawn off from the insoluble residue (fluoride of calcium). By passing carbonic acid gas (obtained from the combustion of coke) through this solution, the soda is converted into the carbonate, and the alumina is precipitated. In wet process, the cryolite is boiled with milk of lime; and according to the proportions of lime employed, the resultant products are caustic soda and aluminate of soda, or, where the proportion of lime is greater, caustic soda and aluminate of lime, fluoride of calcium being formed of course in both cases. The latter process, it will be observed, gives all the soda of the cryolite in the caustic state, the only operation required being evaporation to dryness. In this manner, we are informed, large quantities of soda lye are produced at the Natrona works. The great simplicity of the operation, and the freedom of the crude material from impurities, which is insured by careful selection, renders the soda products obtained for cryolite extremely pure.

The aluminate of soda produced in the operation above described is said to be largely used in the manufacture of soaps, in place of soda and potash lye. It is completely decomposed by passing carbonic acid gas through it, and the resulting alumina which is precipitated is converted into sulphate of alumina and alum. The fluoride of calcium, which is a by-product of the treatment of cryolite, is affirmed to be used in large quantity as a flux in the reduction of gold, iron, and other metals. When finely powdered and mixed with sand in the proportions of one part to three or four of sand, cryolite has come to be used in the manufacture of a beautiful white glass or porcelain ware, which is easily moulded and cut, and is remarkable for its tenacity.

The cryolite industry has attained to a position of great commercial importance, the value of its various manufactures reaching annually to several millions of dollars. The supply of the mineral, from present indications, appears to be unlimited, and the permanency of the industry appears to be therefore assured.—*W., in Polytechnic Review.*

CHROMIUM.

FEW people not chemists have ever seen the metal, the name of which heads our present article, and many have not even heard its name except in the compound chrome-steel, an alloy used for burglar-proof safes. The chromates, however, possess a wider notoriety. Some of these occur in nature, and one of these, the chromate of lead or *crocoite*, from its beautiful red color, gave name to the metal discovered therein by Vauquelin in 1797. The salts prepared from it artificially likewise exhibit beautiful colors, yellow, red, green, and violet, justifying the name, which is derived from the Greek. The principal source of it is now a compound of oxide of chromium with oxide of iron, known as chromic iron, of a brownish black color and scarcely distinguishable from magnetic iron ore, unless tested for chromium by fusion with fluxes.

Metallic chromium is too difficult of preparation, and too hard to fuse, to meet with any use in the arts. As a curiosity it has been prepared in many ways; such as the electrolysis of a solution of the sesquioxide, by passing vapor of sodium over the chloride at a high temperature, by reducing the chloride by zinc, or heating the oxide in contact with lamp-black or sugar charcoal. Its properties differ somewhat with the method of its preparation. According to Deville it is less fusible than platinum;* it is as hard as corundum, at least. The latter property renders it particularly useful when alloyed with steel for safes.

It forms several oxides corresponding to those of iron:

CrO, Chromous oxide; FeO, Ferrous oxide.
Cr_2O_3, Chromic or sesquioxide; Fe_2O_3, Ferric oxide.
Cr_3O_4, Chromoso-chromic oxide; Fe_3O_4, Magnetic oxide.
H_2CrO_4, Chromic acid, H_2FeO_4, Ferric acid?

The protoxides of each are of no importance; the sesquioxides are permanent, are found in nature, and may be prepared artificially by expelling water from the hydrates.

$Fe_2H_6O_6$	$Cr_2H_6O_6$
H_6O_3	H_6O_3
$Fe_2 \quad O_3$	$Cr_2 \quad O_3$

These hydrates are precipitated from solutions by ammonia; one is reddish brown, the other green. The protosesquioxides are obtained by precipitation from a mixture of protoxide and sesquioxide salts, but are of little interest. The chromates differ from the ferrates in possessing great permanence; they are numerous and find very extensive use in the arts, while the ferrates are few in number, decompose readily, and are of no use. The anhydride, FeO_3, has not been obtained, but chromic trioxide, CrO_3, is quite easily prepared from potassic dichromate and sulphuric acid, and is a very useful oxidizing agent. In solution it may replace nitric acid in the Bunsen battery. When pure it consists of long red needles, which are very deliquescent, melt at 190 C. and give off oxygen at 250° C. It is readily reduced to Cr_2O_3 by sugar, alcohol, and other organic bodies; with absolute alcohol enough heat is sometimes liberated to ignite

* Polytechnisches Centralblatt, 1857, p. 605.

the alcohol. Hydrochloric acid converts into chromic chloride, Cr_2Cl_6.

The most important salts of chromic acid are the potassic chromate and dichromate, being the starting-point of the other chromates and of chromic anhydride itself.

The yellow chromate, K_2CrO_4, is made by heating chrome iron ore, previously pulverized and cleansed, with potassic carbonate and nitrate on the hearth of a reverberatory furnace. The sintered but not molten mass is again ground, and the chromate extracted with boiling water. The alumina and silica are precipitated by pyroligneous acid (wood vinegar), and the yellow chromate allowed to crystallize, or it may be at once converted into the red dichromate, $K_2Cr_2O_7$, by adding nitric or sulphuric acid. When nitric acid is employed, the potassic nitrate is recovered for future use:

$$2K_2CrO_4 + 2HNO_3 = K_2Cr_2O_7 + 2KNO_3 + H_2O.$$

Among the remarkable properties of this salt is its action upon gelatine and glue. When potassic dichromate is mixed with gelatine, the mixture is rendered sensitive to light, being made insoluble by it. If a glass plate bearing an even film of gelatine, sensitized with this salt, is exposed under a photographic negative to the action of the sun's rays, the exposed portions become insoluble. On removing it to the dark room and placing it in warm water, the protected portions are dissolved out, leaving a relief positive picture. This is the principle lying at the base of the various photo-printing and engraving processes.

Potassic dichromate is also employed in solution for preserving anatomical specimens. By exposure to light the nitrogenous portions are rendered insoluble and thus protected from decomposition, the object becoming a kind of mummy. For a similar reason, as in the two cases above mentioned, potassic dichromate may be employed in making waterproof glue or cement, for glass or other transparent articles, and for waterproofing paper and textile fabrics. It is, however, poisonous, and care must be used to prevent too frequent contact of the chromate with the skin.

With lead chromic acid forms two salts, one red, and the other yellow, both of which are used as pigments. When potassic chromate or dichromate is mixed with the solution of any lead salt, a yellow precipitate of plumbic chromate, $PbCrO_4$, is formed. If to the mixture an alkali be added and heat applied, a basic chromate, $2CrO_3,CrO_3$, of a bright red color, is produced. By slightly varying the operation, any shade of orange can be obtained. The finest vermilion red chromate is formed when 1 part of chrome yellow is thrown into 5 parts of nitre in a state of fusion, and the resulting chromate of potassium, together with the excess of nitrate, dissolved out by water; the basic chromate of lead then remains in the form of a crystalline powder. Either the yellow or orange may be applied to cloth by first printing upon it with acetate of lead and then dipping it into potassic dichromate. The yellow thus formed is converted into orange by immersing it in milk of lime at the boiling temperature.

Chrome green, sometimes called green cinnabar, is a mixture of chrome yellow with Prussian blue. It is much preferable to Paris green for all purposes. It is now employed for printing "greenbacks," instead of the sesquioxide, which was employed at first. Although the latter is itself indestructible, it proved very destructive to the plates from which the notes are printed. For painting on porcelain and china the sesquioxide must long hold its own, not being injured, as most pigments are, by the highest temperatures.

Basic chromate is obtained by precipitating potassic chromate with basic chloride or hydrate, and has been employed as a pigment under the name of *yellow ultramarine*. Potassic chromate is also used as a test for barium, as the other alkaline earths do not yield precipitates with potassic chromate.

Chromium forms an alum isomorphous with common alum, but of a dark purple color. It may be obtained by the action of sulphuric acid on potassic dichromate, and often forms spontaneously in galvanic batteries where this mixture is employed.

Most of the other compounds of chromium are of merely theoretical interest. E. J. H.

PREPARATION AND USE IN CASTING STEEL OF ALLOYS OF SILICON AND MANGANESE.

By SERGIUS KERN, St. Petersburg.

IN a recent communication of M. Gautier to the Iron and Steel Institute, on "Solid Steel Castings," the author called attention to some metallurgic experiments made during the last few years in France, at the Terre Noire Works, in order to obtain solid steel castings—that is to say, ingots of steel without the well-known peculiar blowholes, which are due, as Mr. Bessemer showed, to the presence of carbonic oxide (CO), which, while the steel is in a melted state, is dissolved in it, and when the liquid metal commences to solidify an excess of carbonic oxide escapes, as liquid steel dissolves more of this gas than the solidifying mass. This remaining gas, which had not time to escape, gives rise to these blowholes, which much injure the uniformity of castings. Mr. Bessemer used, a long time since, silicon iron in order to prevent the formation of blowholes. Silicon acts chemically on the carbonic oxide by the following reaction:

$$2CO + Si = SiO_2 + 2C.$$

Thus the formation of blowholes is prevented, and in the mass of the ingot carbon and silica are deposited in a finely divided state. Mechanical experiments proved that the resulting ingots give steel with a very high degree of tension.

It must be mentioned that the free carbon which is deposited in the metal when the silicon alloy is added to the metallic bath of the furnace acts very energetically on the oxides of iron, which cannot be entirely reduced by the addition of ferro-manganese. The carbon acts on the oxides of iron as follows, yielding carbonic oxide, which is, secondly, destroyed by the addition of a rich alloy of silicon:

$$Fe_2O_3 + 3C = 3CO + Fe_2; \text{ or}$$
$$2FeO + 2C = 2CO + Fe_2.$$

My experiments show that it is preferable to use an alloy of silicon, manganese, and iron, in order to reduce in the same time the iron oxides of the metallic bath by the manganese of the alloy, and to prevent the formation of blowholes in the ingots by means of the silicon of the alloy. By using an alloy of such kind we kill two birds with one stone.

I prefer the use of alloys with 70 to 75 per cent. of manganese, 18 to 16 per cent. of iron, 10 to 6·50 per cent of silicon, 2 to 2·50 per cent. of carbon, and foreign matter. In melting steel in Siemens-Martin furnaces, at the end of the operation about 1 to 1¼ per cent. by weight of this alloy is added to the metallic bath. The results of the use of such an alloy are highly favorable: the cast steel obtained gave the following results on being mechanically tested:

	Tons per square inch.	
	Legan to Stretch.	Breaking Weight.
Sample No. 1	24·8	48·5
" No. 2	27·2	48·8
" No. 3	26·7	49·2

The same alloy is recommended by M. Gautier for the purpose of obtaining solid steel castings; at Terre Noire it is prepared in blast furnaces. But as not every steel foundry has furnaces of such kind, it is desirable to obtain this alloy in a foundry having at its disposition only the ordinary coke crucible furnaces.

The following process may be used for the production of silicium alloys with ferro-manganese. The alloys contain 6 to 10 per cent. of silicon; an alloy containing 6 per cent. of silicon and 60 to 70 per cent. of manganese is quite suitable for metallurgic purposes. The raw mass consists of—

	Pounds.
Ferro-manganese (60 to 70 per cent. of manganese, 6 to 7 per cent of carbon)	220
Iron in small strips	25
Quartz of good quality	100
Calcium fluoride ($CaFl_2$)	155
	500

All these substances, in a form of powder, are mixed with the iron in strips and coal tar in such a quantity as to obtain a pasty mass, which is well dried and divided in four parts, and is placed into four crucibles. The thickness of the crucibles should be from 1¼ to 1½ of an inch. The crucibles, with well fitted covers, are placed in coke furnaces for about five hours. The resulting alloy contains 6·650 per cent. of silicon, a quantity ordinarily quite sufficient. The alloy generally contains 1 to 1·50 per cent. of carbon, nearly all the carbon of the ferro-manganese being reduced in the form of graphite, which is found in the middle of the ingot. This graphite, by breaking the ingot, may be easily separated. By using ferro-manganese with a higher percentage of carbon, and increasing the quantity of quartz and calcium fluoride in the above-mentioned mixture, alloys with 7 to 12 per cent. of silicon may be obtained.

The following is the explanation of the use of calcium fluoride proposed by me for the preparation of silicon manganese alloys: Calcium fluoride with quartz firstly gives the following products:

$$12CaFl_2 + 4SiO_2 = 4CaSiFl_6 + 8CaO.$$

The calcium silico-fluoride next very easily gives silicon to the melting ferro-manganese alloy; the resulting calcium oxide forms, with the remaining quantity of quartz and a certain quantity of manganese, a liquid slag, preventing well the liquid metal from further oxidation.

This process gives silicon-manganese alloys with less expense than by melting ferro-manganese with quartz alone.—*Chemical News.*

ON THE METALS WHICH ACCOMPANY IRON.

By M. A. TERREIL.

THE numerous analyses that I have made during several years of the principal ores of iron, and of their metallurgic products, have convinced me that iron, like platinum, is almost always accompanied in its ores by several metals which are found in the metallurgic products of this metal, and which I shall call the metals of iron ores. These metals, besides manganese, which has always been mentioned, are principally magnetic metals of the family of iron, such as nickel, cobalt, and chrome, the presence of which was considered as characteristic of meteoric irons. They are found, according to my observations, in almost all iron ores. These metals ordinarily escape analytical research by reason of their small proportion relatively to the mass of iron, and also because the ammoniacal salts, which are produced in the analytical operations, completely mask the properties of these metals. Besides these metals of iron ores, irons, cast-irons, and steels contain also several accidental metals, which are copper, vanadium, titanium, and tungsten.

To detect these metals which accompany iron in the mine, I have adopted an analytical method, which I shall describe: After having treated the substance in the ordinary way, either by *aqua regia* or by muriatic acid and chlorate of potash, I filter, to separate the part insoluble in the acids, and after having washed the latter with great care in distilled water, I pour gradually, whilst stirring, the filtrate into ammonia. I avoid, as is seen, to pour the ammonia into the acid liquid; this precaution is very important, for in this last case the oxides soluble in ammonia remain fixed to the oxide of iron which is precipitated. I throw the precipitate obtained on a filter, and wash with distilled water. At this point of the analysis the metals of the ores of iron are divided into three groups:—(1) The metals which are found in the residue insoluble in acids, titanium and tungsten; (2) the metals precipitated along with the oxide of iron, chrome and vanadium; (3) the metals in solution in the ammoniacal liquor, copper, nickel, cobalt, and manganese.

I establish the presence of metals in the first group by treating, first, the insoluble residue upon the filter by ammonia, which dissolves the tungstic acid. The ammoniacal liquor, evaporated to dryness and slightly calcined, leaves the tungstic acid in the form of a greenish yellow powder, easy to characterize by the blowpipe. I dry afterwards the insoluble residue, and then treat with concentrated and boiling sulphuric acid, which dissolves titanic acid. I let cool, dilute with water, filter, and treat a portion of the liquid with zinc. The presence of the titanium is then indicated by the violet coloration which the liquid takes on adding zinc. In this case the other portion of the liquor is evaporated so as to drive off all the sulphuric acid, and I obtain thus a white residue of titanic acid, equally easy to recognize with the blowpipe. In all these cases this evaporation to dryness is necessary, even when zinc does not produce a violet coloration of the liquid; this coloration being no longer appreciable when there is too little titanic acid in solution.

To detect the presence of metals of the second group, chrome and vanadium, which were precipitated with oxide of iron, I employ the following method, which consists in suspending the precipitate of oxide of iron in a solution of pure potassa heated up to 90°. We then add permanganate of potash as long as the latter is decolorized. The permanganate transforms chrome and vanadium into chromate and vanadate of potassa. After this transformation, which is complete when the solution takes a green color, we filter, saturate the alkaline liquor with acetic acid, filter a second time, when there is a production of oxide of manganese derived from the excess of permanganate employed, then into a portion of the liquor we pour a few drops of acetate of lead. There is produced a yellow precipitate of chromate of lead, which may be mixed with vanadate of lead. Vanadium is detected in the other portion of the liquor by adding a solution of tannin recently prepared. The vanadic acid slowly forms then with tannin a blue-black or greenish black precipitate, although the liquid is immediately colored. When the yellow precipitate of chromate of lead contains vanadate of lead, it is likewise colored a black-blue or a greenish black, when it is moistened with the solution of tannin.

I recognize the metals of the last group in the following manner: I add to the ammoniacal liquor which contains them a few pieces of pure potassa. I raise to a boil to drive off the ammonia and to decompose the ammoniacal salts, and I heat until the ammoniacal odor has completely disappeared. The potash precipitates the metals in the state of oxides. I collect these oxides on a filter, wash, and take a small portion, which I treat on a plate of silver with melted potassa and niter. To recognize manganese, finally, I dissolve the rest of the oxides in hydrochloric acid. I separate copper by sulphuretted hydrogen, and after the filtration of sulphide of copper I heat the filtrate to drive of the excess of sulpuretted hydrogen, and to concentrate this solution as much as possible. I finally treat with ammonia. The blue-violet tint which the liquor takes indicates sufficiently the presence of nickel. As for the cobalt, I detect it in the following manner:—I pour into the ammoniacal liquor a few drops of permanganate of potash, which peroxides the cobalt, and which precipitates the manganese. I heat some minutes, so that the precipitation of manganese may be complete, filter, supersaturate with muriatic acid, and after adding a little alcohol wait twenty-four hours. I then find at the bottom of the liquor a violet-rose precipitate of roseo-cobaltic hydrochlorate (discovered by M. Fremy) quite characteristic. The liquor treated with potash gives a precipitate of oxide of nickel of an apple-green color.

As to the proportions of metal which accompany iron, they are ordinarily very slight in the metallurgic products which I have had occasion to treat, they rarely attain a total of five-thousandths, whilst in the native or meteoric irons these proportions reach 10 per cent. These differences are sufficient to serve to distinguish meteoric irons from common irons, but I must recall that M. Daubrée on melting peridote obtained a cast-iron, in which I found 1·6 per cent of chrome and 1·16 per cent of nickel; an important fact, for it may throw some doubt on the extra-terrestrial origin of certain irons supposed to be meteoric.—*Bulletin de la Soc. Chimique de Paris.*

PHYLLOCYANIN AS A REAGENT.

THE blue coloring matter of flowers, *phyllocyanin*, is extremely sensitive to minute traces of free alkali, and although the blue solution cannot be preserved, yet when a small quantity of sulphuric acid is added, the red solution thus produced may be kept for a long time without undergoing alteration. The quantity of acid added should not be so large as to give a distinct red color, but merely enough to change it to a dark purple, intermediate between the blue and red. In this state it is capable of showing distinctly the alkaline reaction caused by the presence of ammonia in rain-water, or by the plumbic hydrate in water which has been in contact with metallic lead. Added to a solution of one part of potassium hydrate, in 1,200,000 parts of water, it produces a permanent *blue* color, whilst with a solution in 200,000 parts of water a permanent *green* is obtained. It is, therefore, a much more delicate test than litmus, which scarcely gives any reaction with the last-mentioned solution.

Paper prepared with a solution of phyllocyanin must be kept in well-closed bottles; for, although unaffected in a vacuum or by air which has been exposed over sulphuric acid, yet, when it is exposed freely to the air, the ammonia present in it turns the color blue.

The phyllocyanin is best obtained from the iris, the violet, or the purple verbena, by treating the petals with a small quantity of warm water; sulphuric acid is then added until it assumes a purple color, and the solution is preserved in a closed vessel excluded from the light.—G. PELLAGRI, *in Gaz. chim. Ital.*

PENCILS OF SILVER NITRATE.

VERY thin pencils of caustic, such as are sometimes required for intra-uterine applications, may be prepared, according to A. Huber, in the following manner: Silver nitrate is fused in a capsule, and the liquid drawn up, by slow and cautious suction, into a glass tube, the calibre of which is a trifle larger than the required diameter of the pencil. Especial care is to be taken that no cavities filled with air-bubbles are produced in the contents of the tube. When entirely cold, the glass tube is warmed by turning over a spirit-lamp, until the outer surface of the stick has become soft, when it may be easily pushed out by means of a knitting needle. With a little practice, very handsome pencils, of considerable length, may be obtained in this manner.—*Schweiz. Woch. f. Pharm.*

PHOTO STEREOTYPING.—The name of photo-stereotyping is given to a new and ingenious process of its kind, just introduced in London. A sheet of ordinary plate glass, larger than the picture to be reproduced, is coated in a dark room with a solution made by dissolving one ounce of potassium bichromate in fifteen ounces of water, warming gradually, and then adding two ounces of fine gelatine and filtering through linen at the boiling heat. Now, a diapositive is taken from an ordinary negative, and laid with the collodion side to the gelatine face of the prepared plate, in diffused light, for ten to thirty minutes. The plate is then taken from the frame in the dark room, and washed with water for five or ten minutes, till the relief is wholly developed, after which it is dried with filtered paper and coated with glycerin by means of a camel's hair pencil, and the excess of liquid is removed with filter paper. From the plate prepared according to this process, a cast is made in plaster of Paris of the thickness or consistency of oil, and from the plaster cast thus obtained a metal one can be taken in the usual manner.